MICROWAVE PATH SURVEY REPORT

RADIO FREQUENCY INTERFERENCE (RFI) MEASUREMENT REPORT

Prepared For

ViaSat

Columbus, OH

Transmit and Receive Earth Station
17-21 GHz and 27-31 GHz

February 06, 2015

19700 Janelia Farm Boulevard. - Ashburn, Virginia 20147, USA - 703.726.5500 - Fax 703.726.5597

TABLE OF CONTENTS

SECTION

ONE

SECTION 1

INTRODUCTION AND BACKGROUND

1.1 Introduction

On-site Radio Frequency Interference (RFI) measurements were performed on behalf of ViaSat, Inc. on February 6, 2015, at their proposed site in Columbus, OH. The purpose of these measurements was to determine the relative RFI levels in the 17-21 and 27-31 GHz common carrier frequency band and their impact on digital down-link satellite reception. Measurements were performed at one designated location. The purpose of this report is to document the results of these measurements and to present recommendations.

The analysis in this report is based upon the following:

- Andrew 4.1 Meter Antenna
- Satellite Arc: 55 to 115 Degrees West Longitude
- Frequency Range Considered: 17 to 21 GHz and 27-31 GHz
- Interference Objective: -156 dBW/1 MHz
- Type of Reception: Digital
- Measured Antenna Center Line: 6.5 Feet Above Ground Level

1.2 Background

ViaSat, Inc is proposing to locate a new transmit/receive antenna at a new location of 39^0 58' 51.7" N and 082^0 59' 32.3" W ViaSat, Inc had requested that Comsearch conduct RFI measurements at the facility to assess the interference potential. This facility is currently nonoperational and measurements were done at a point near the proposed antenna locations.

The measured site is identified on a portion of a topographic map shown in Figure 1.2-1. An aerial photo of the site location is shown in Figure 1.2-2. A photo of the measurement using a GPS is shown in Figure 1.2-3. A photo of the surrounding cellular/PCS coverage is shown in Figure 1.2-4.

1.3 Constraints

The analysis in this report is based upon the following assumptions and constraints.

- The antenna selected will conform to the FCC reference pattern 32-25 Logθ as specified in 47CFR 25.209(a)(2).

- It is assumed that during the measurement period all of the terrestrial transmitters were active and operating at full transmit power for the licensed frequencies unless otherwise noted.

- The signal identification and frequencies analyzed are based upon information obtained from the various common carriers as to what frequencies were active at the time of the measurements and the traffic these frequencies were supposed to be carrying.

- The actual ground elevation of the site is based on the data from the topographic map.

- The interference objective of –156 dBW/1 MHz used throughout this report is based upon estimated link budget parameters and is subject to change. ViaSat, Inc should review the system parameters for this down-link in order to verify the viability of this objective.

Figure 1.2-1 - Topographical

Figure 1.2-2 – Aerial Photograph

Figure 1.2-3 – GPS Photograph

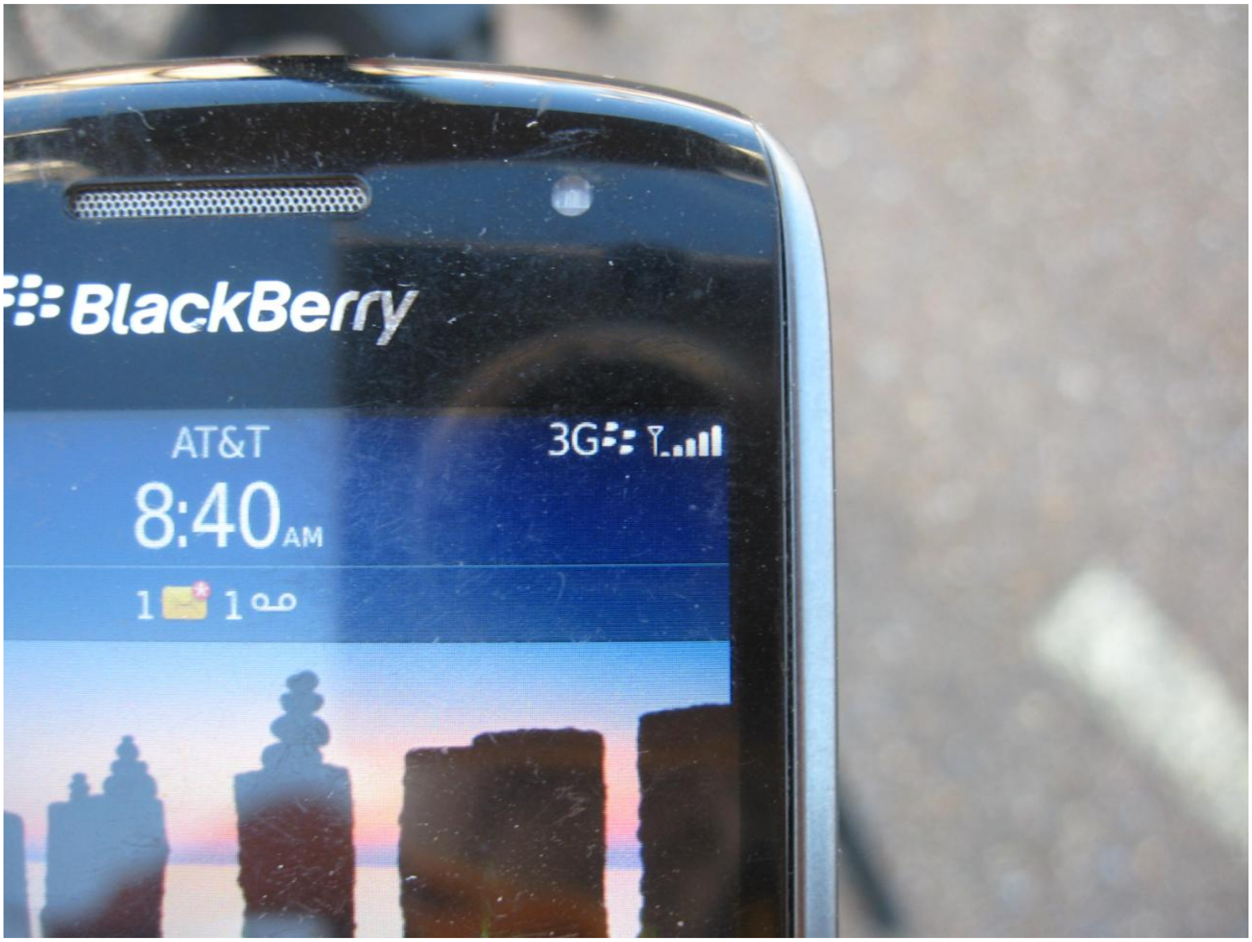

Figure 1.2-4 – Cellular/PCS Coverage

SECTION

TWO

SECTION 2

TEST PROCEDURE

2.1 Calibration

Figures 2.1-1 is the block diagram of the test set for all bands to be tested. All test equipment used was allowed a proper warm-up period prior to calibration. The test set was calibrated by the signal substitution method, as recommended by NSMA, utilizing a synthesized signal generator. The reference signal from the signal generator was adjusted for the center frequency of each band to be tested and measured with a thermal power meter for calibrated reference test level (-60 dBm). This calibrated reference signal from the signal generator was then injected into the end of the coaxial cable of the test set at the point, which normally connects to the test antenna. A spectrum analyzer then measured the reference test signal level after passing through the test set. At this point, the spectrum analyzer was calibrated such that the top graticule of the spectrum analyzer display (-60 dBm) corresponded to the injected reference signal (-60 dBm) by utilizing the reference level offset function of the Anritsu –M52720T spectrum analyzer. Upon completion of the calibration process, a known reference level was obtained for the measurements that correspond to a given set of spectrum analyzer display readings.

The following formula is used to transform the measured signal level as read on the spectrum analyzer display (dBm) to an isotropic reference signal level (dBW_I) as seen at the point of test:

$$dBW_I = LI - GA - 30$$

Where: dBW_I = Isotropic level in dBW

LI = Level (dBm) of injected signal

GA = Test antenna gain

-30 = Conversion factor from dBm to dBW

at 19.5 GHz: $dBW_I = -60\text{ dBm} - 30\text{ dB} - 30\text{ dB}$

$= -120\ dBW_I$

In this instance, the spectrum analyzer displayed measured signal level of –60 dBm equates to an isotropic signal level of –120 dBW_I.

Figures 2.1-2(A-H) displays the spectrum photographs of the described calibration procedure employed during these measurement.

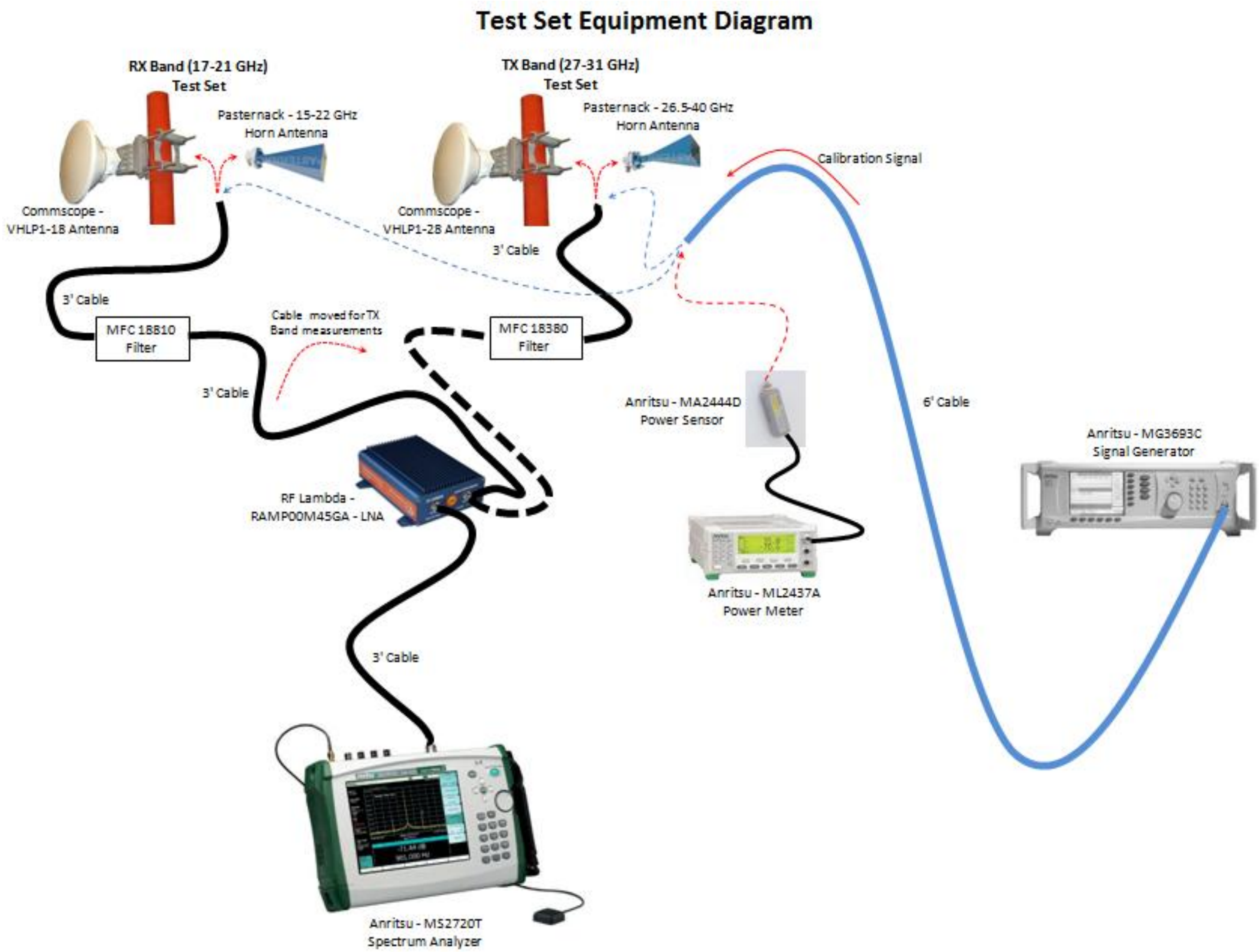

Figure 2.1-1 Receive Test Equipment Block

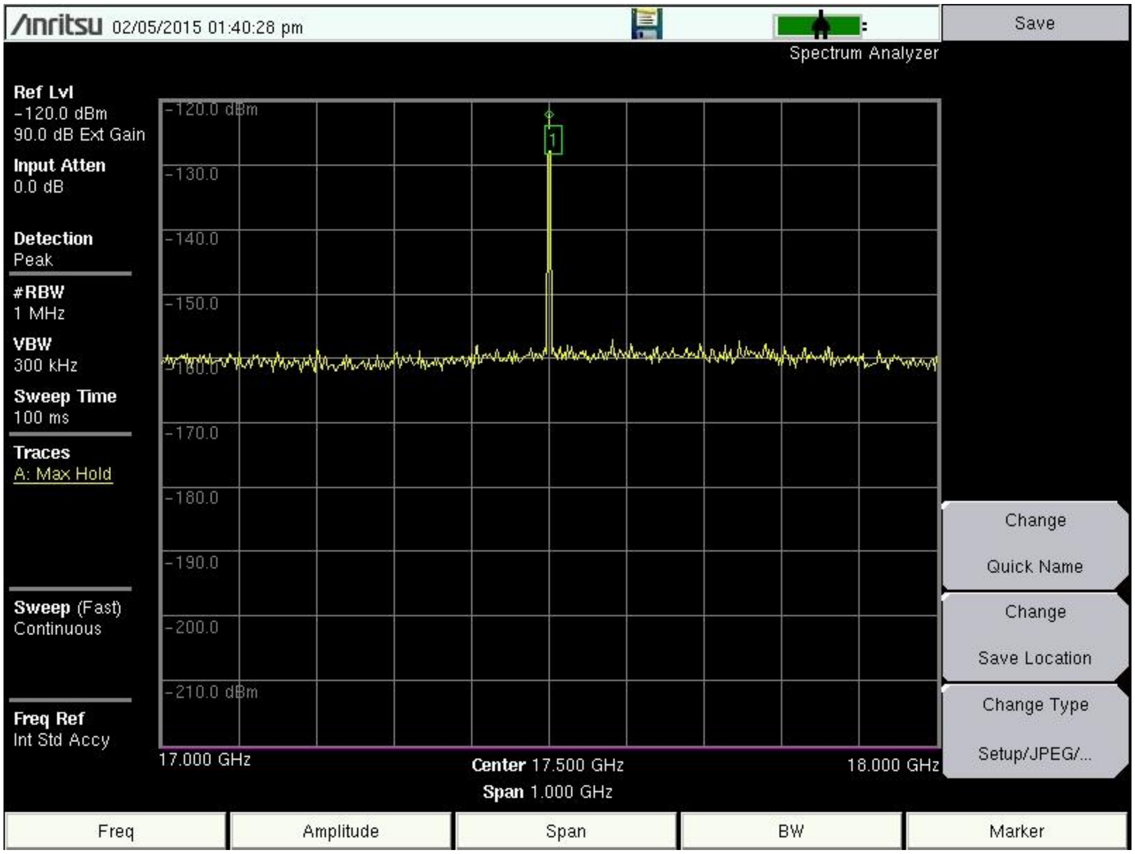

Figure 2.1-2 (A) Calibration Spectrum Photo 17.5 GHz

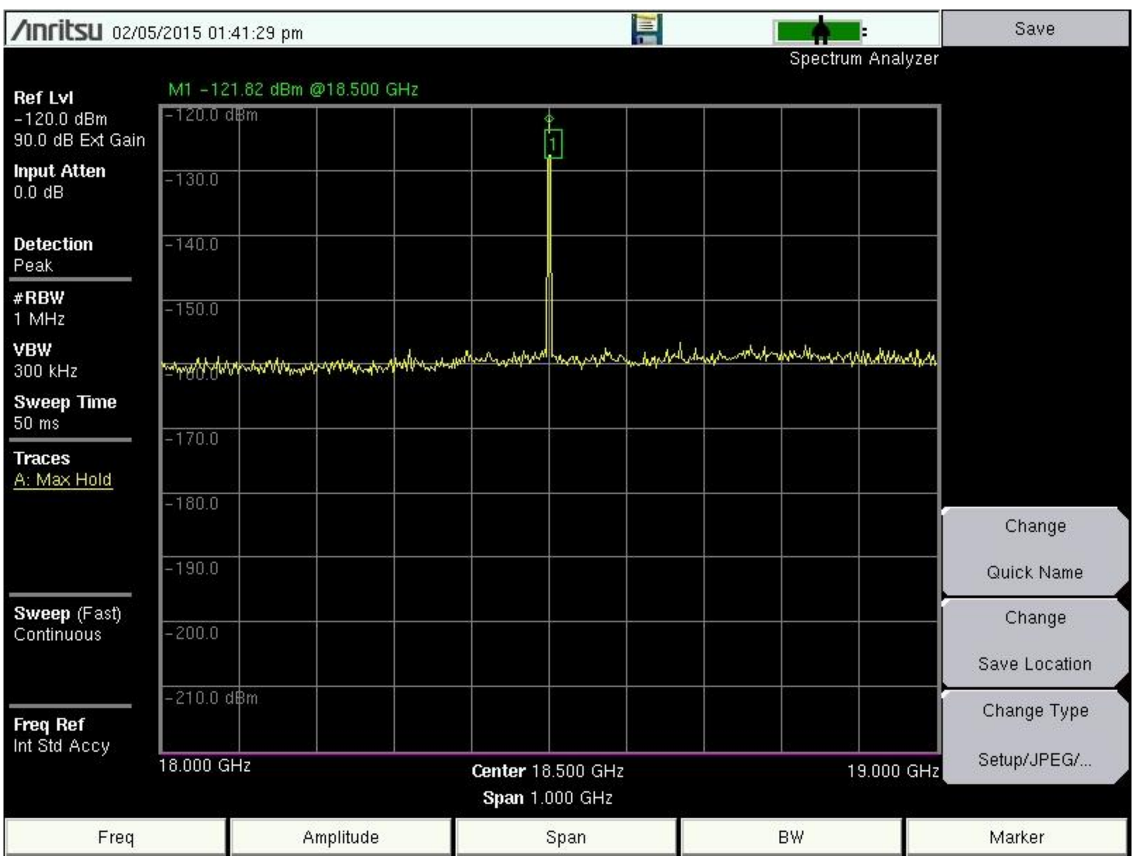

Figure 2.1-2 (B) Calibration Spectrum Photo 18.5 GHz

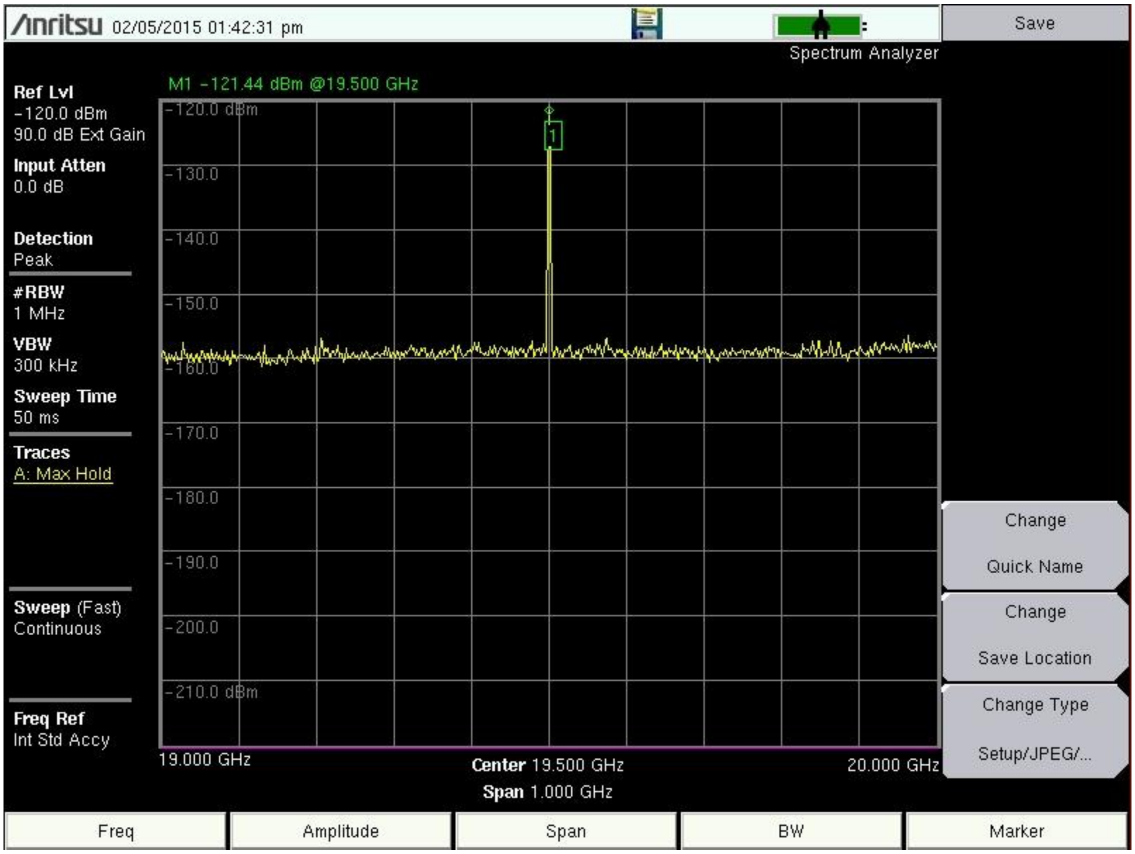

Figure 2.1-2 (C) Calibration Spectrum Photo 19.5 GHz

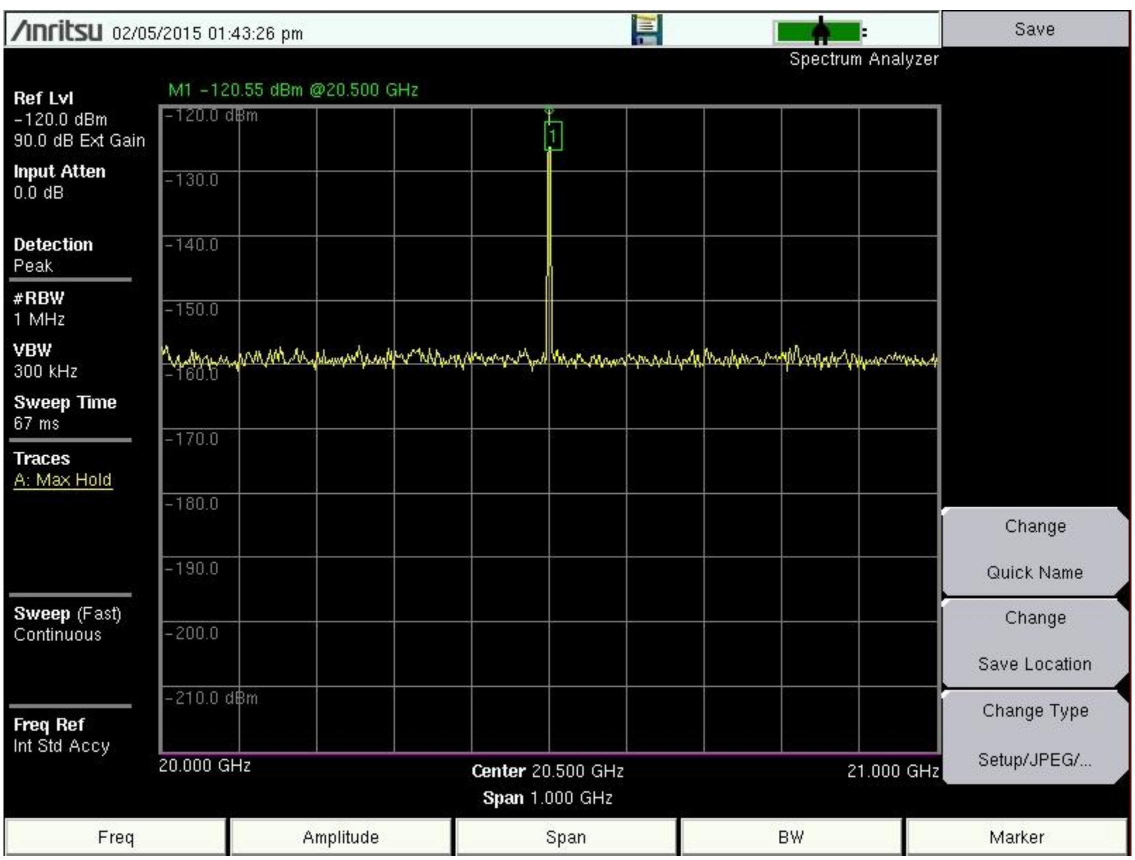

Figure 2.1-2 (D) Calibration Spectrum Photo 20.5 GHz

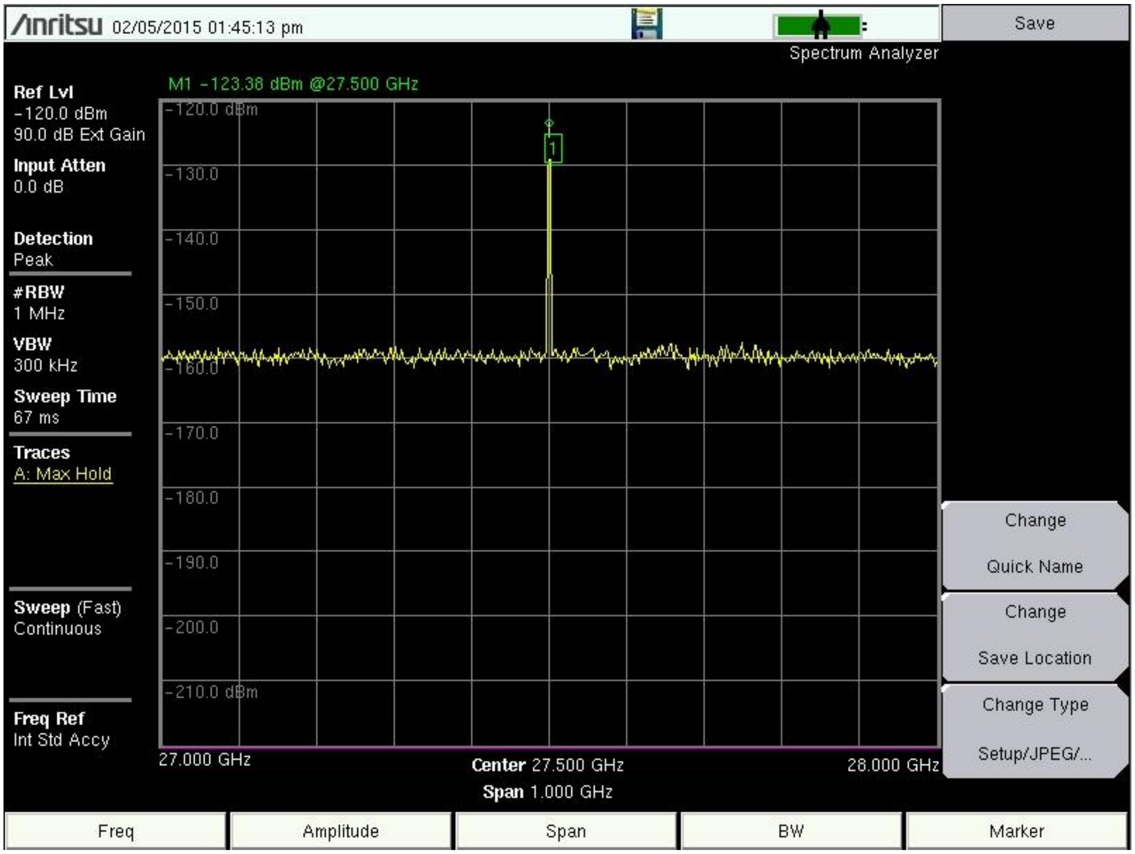

Figure 2.1-2 (E) Calibration Spectrum Photo 27.5 GHz

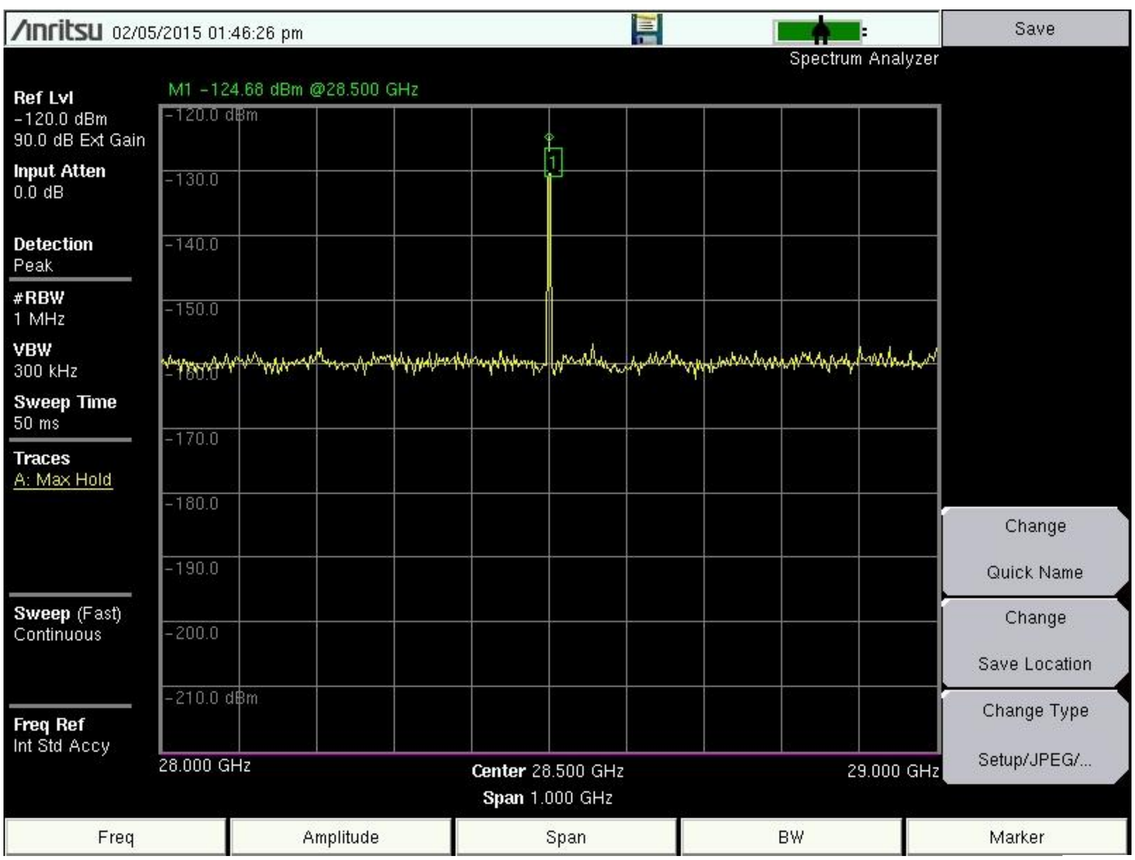

Figure 2.1-2 (F) Calibration Spectrum Photo 28.5 GHz

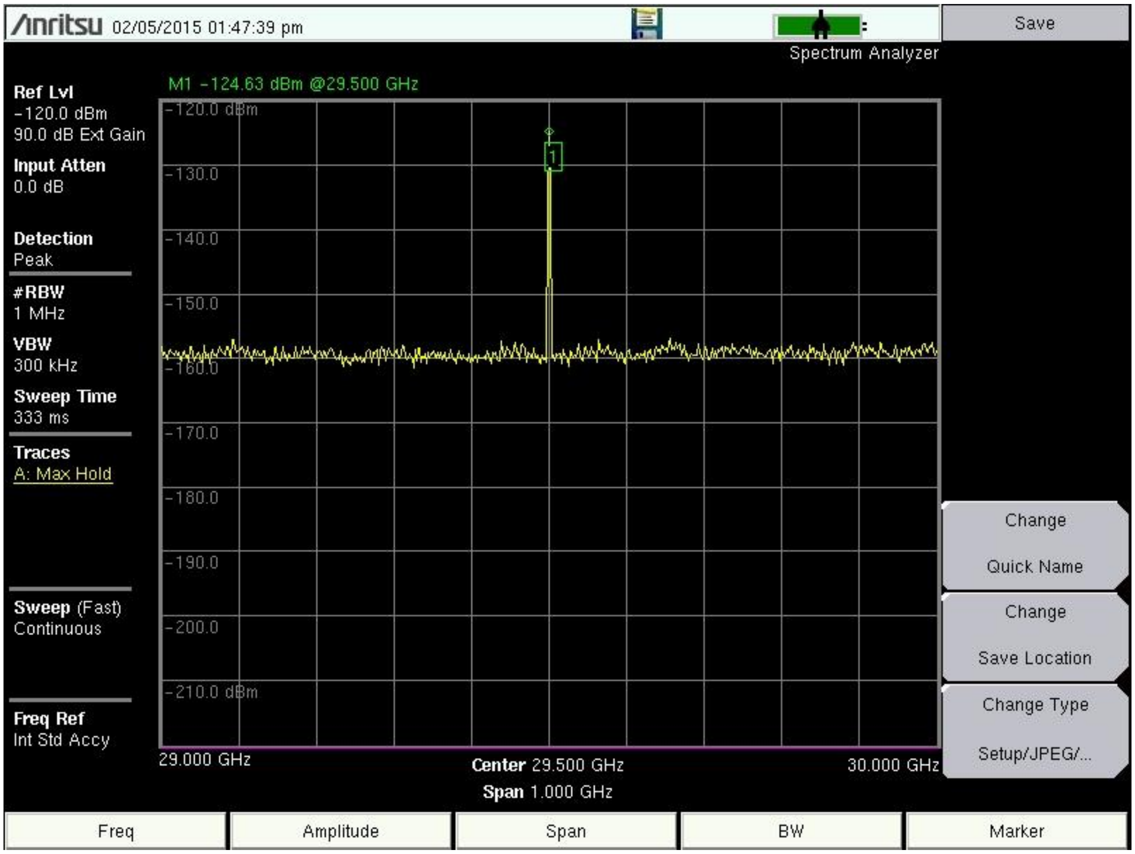

Figure 2.1-2 (G) Calibration Spectrum Photo 29.5 GHz

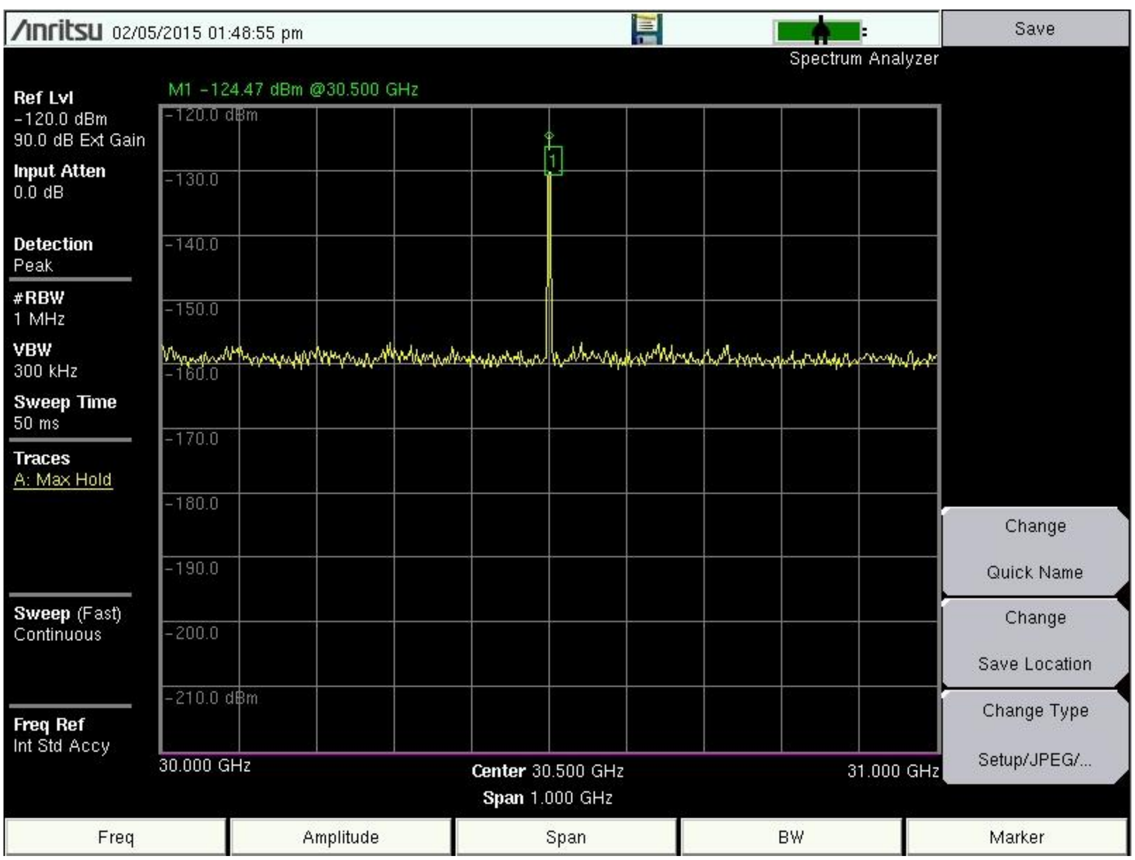

Figure 2.1-2 (H) Calibration Spectrum Photo 30.5 GHz

COMSEARCH

2.2 Methodology

Upon arriving at the existing earth station site, azimuth and horizon elevation measurements were performed to evaluate if any satellite arc obstructions exist. The coordinates of the existing earth station site were verified on the DeLorme topographic map. Photographs were taken to document the satellite arc (clearance) and are included in this report.

After site coordinates and horizon elevations were verified, the test equipment was set up and calibrated to measure the RF environment. Measurements were conducted at the proposed earth station location for the 17-21 and 27-31 GHz band. After the equipment calibration was completed, the test antenna was mounted on an extendable tower and elevated to a height of 6.5 feet. This height is greater than the centerline of the earth station antenna. The antenna was rotated 360 degrees (scanning), once in each polarization, while activating the peak hold function of the spectrum analyzer. This enabled the analyzer to maintain and display the maximum signal level received for all frequencies under consideration. After the initial documentation of interference, all interference conflicts if observed were peaked on to determine the azimuth and the level of the interference source.

Upon completion of the RF testing, the measured signal levels were transposed to earth station interference levels after accounting for the addition of the corresponding earth station antenna gain.

SECTION

THREE

SECTION 3

DATA PRESENTATION

The following section contains the tables and spectrum photos pertaining to the site location measured.

3.1 Columbus, OH

- Table 3.1-1 presents a site data sheet including all pertinent site information.

- Figures 3.1-1 and 3.1-2 are the photographs depicting the existing earth station site and satellite arc.

- Figures 3.1-3 through 3.1-10 are the RF spectrum photographs depicting the interference environment at the test site.

TABLE 3.1-1

MEASUREMENT SITE DATA SHEET

1.	SYSTEM NAME:	ViaSat, Inc	
2.	CITY AND STATE:	Columbus, OH	
3.	SITE IDENTIFICATION:	Columbus	
4.	COORDINATES: (NAD 1983)	LATITUDE: LONGITUDE:	39° 58’ 51.7” N 082° 59’ 32.3” W
5.	GROUND ELEVATION:	789 feet AMSL	
6.	MEASUREMENT DATE AND TIMES:	February 06, 2015	
7.	GEOSTATIONARY ARC RANGE:		
	SATELLITE POSITIONS:	55W – 115W	
	AZIMUTH:	140.4° – 231.3°	
	ELEVATION:	35.3° / 33.3°	
8.	GEOSTATIONARY ARC VISIBILITY:	Satellite arc has no blockage at this time	

North

East

Figure 3.1-1 Earth Station Site Photographs

South

West

Figure 3.1-1 (cont.) Earth Station Site Photographs

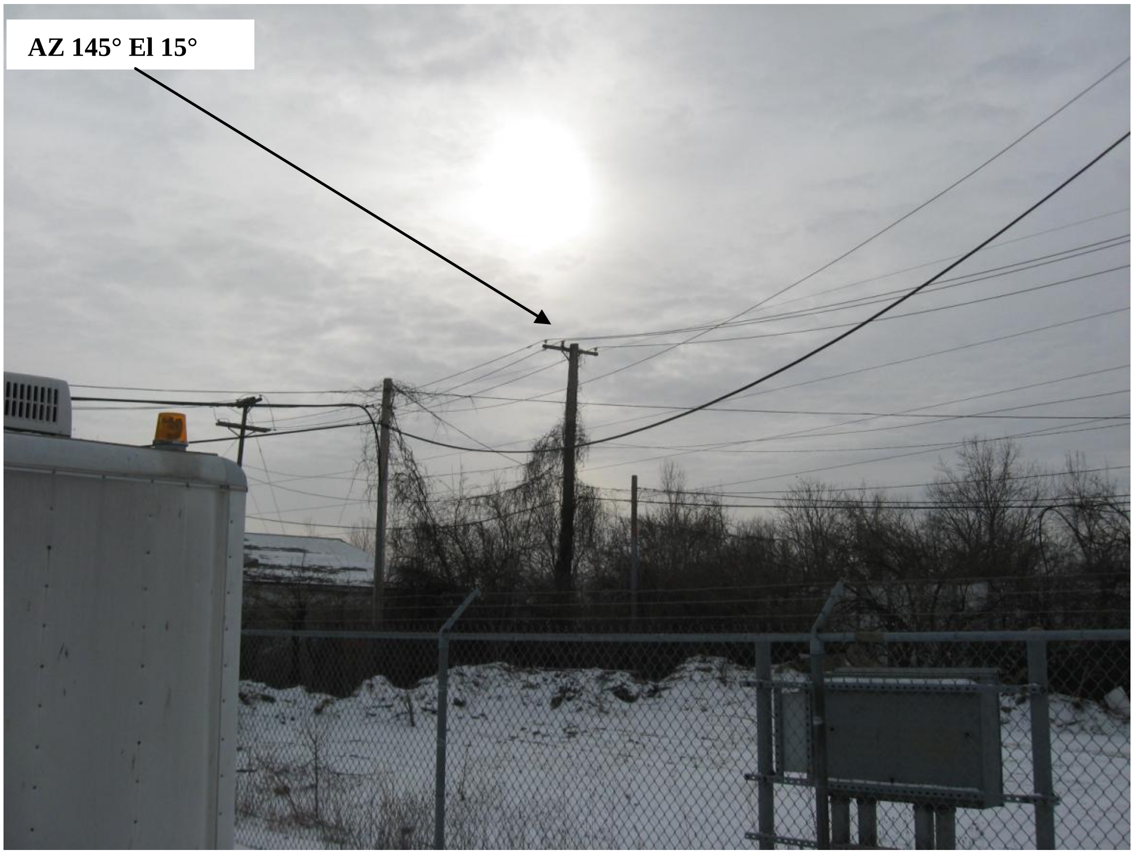

Figure 3.1-2 Horizon Photographs of Earth Station Site

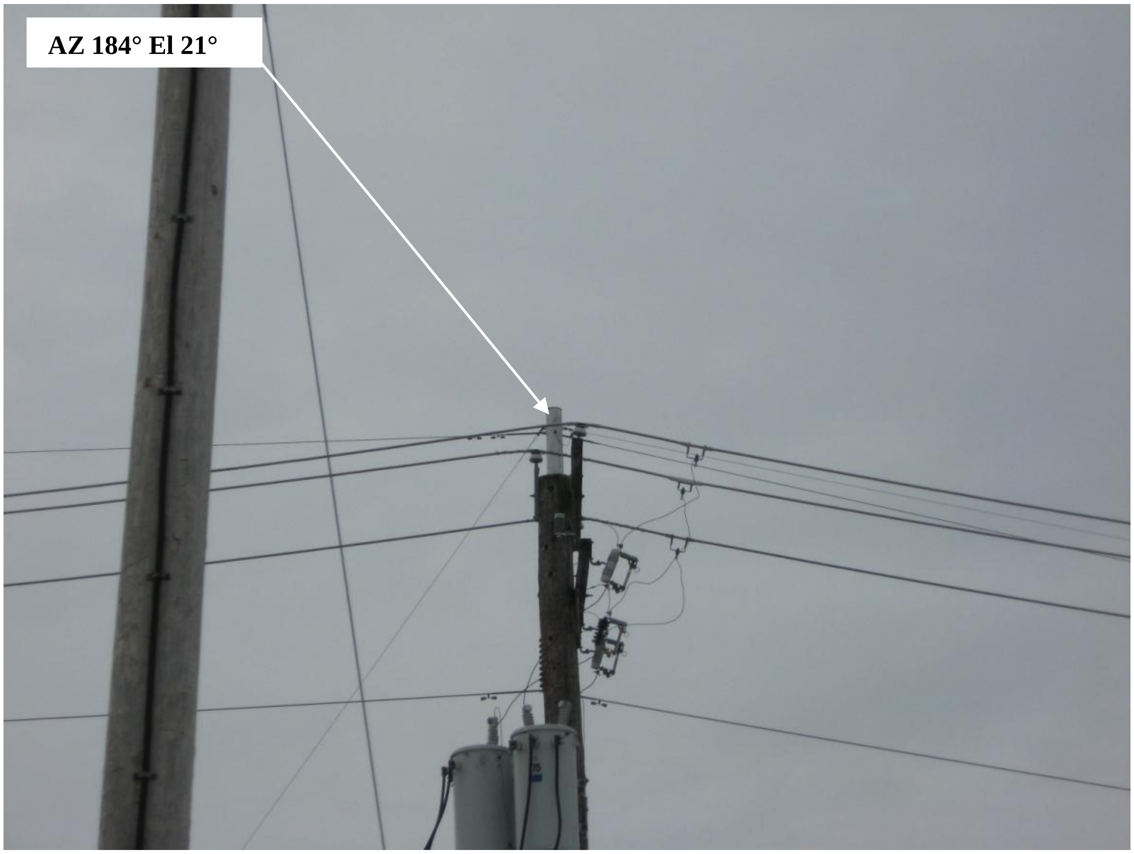

Figure 3.1-2 (cont.) Horizon Photographs of Earth Station Site

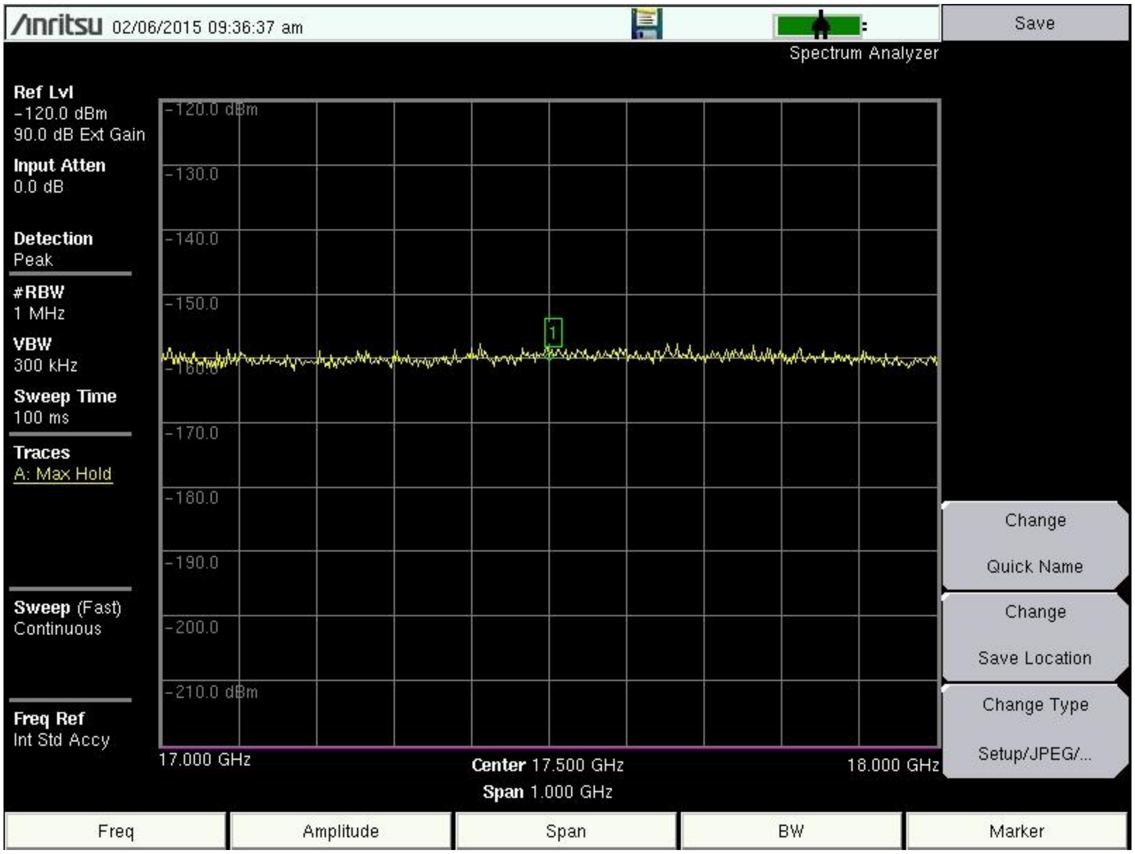

Figure 3.1-3 (A) Spectrum Photos 17-18 GHz 1MHz Res BW Horizontal Pol 360^0

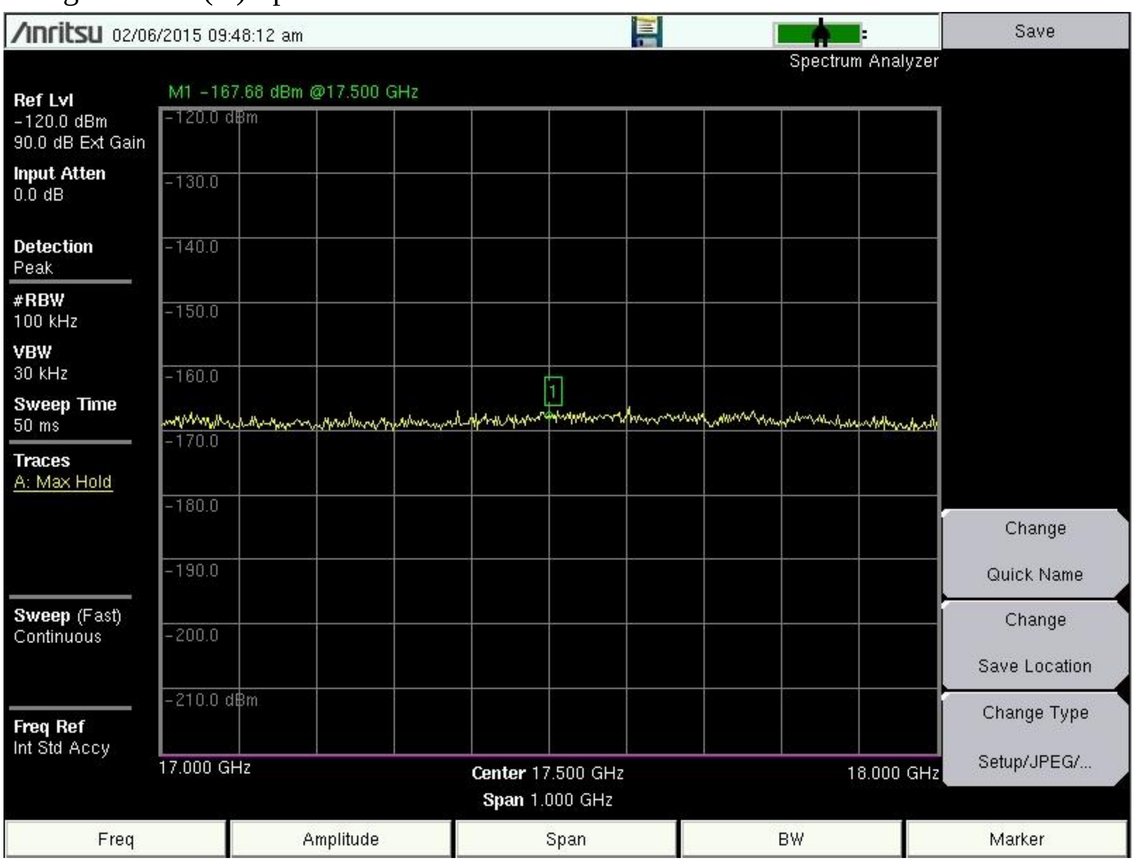

Figure 3.1-3 (B) Spectrum Photos 17-18 GHz 100 KHz Res BW Horizontal Pol 360^0

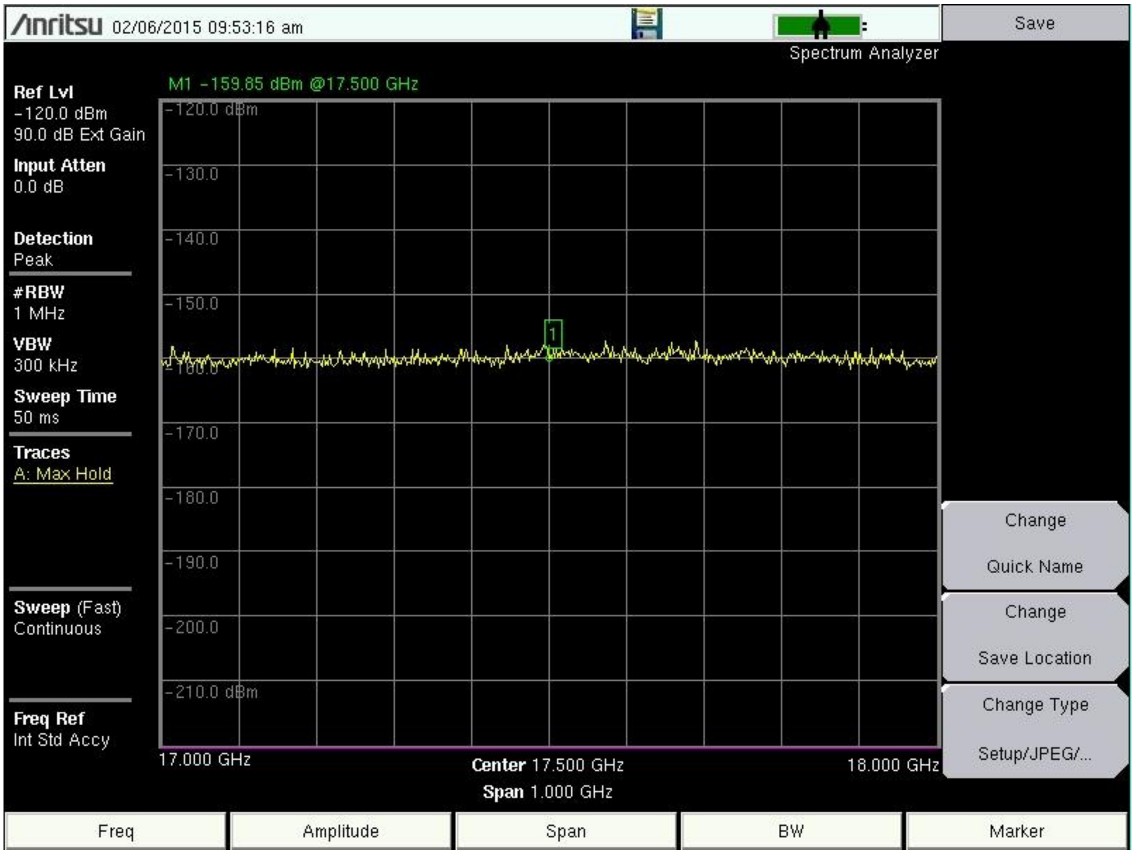

Figure 3.1-3 (C) Spectrum Photos 17-18 GHz 1MHz Res BW Horizontal Pol Worst Case

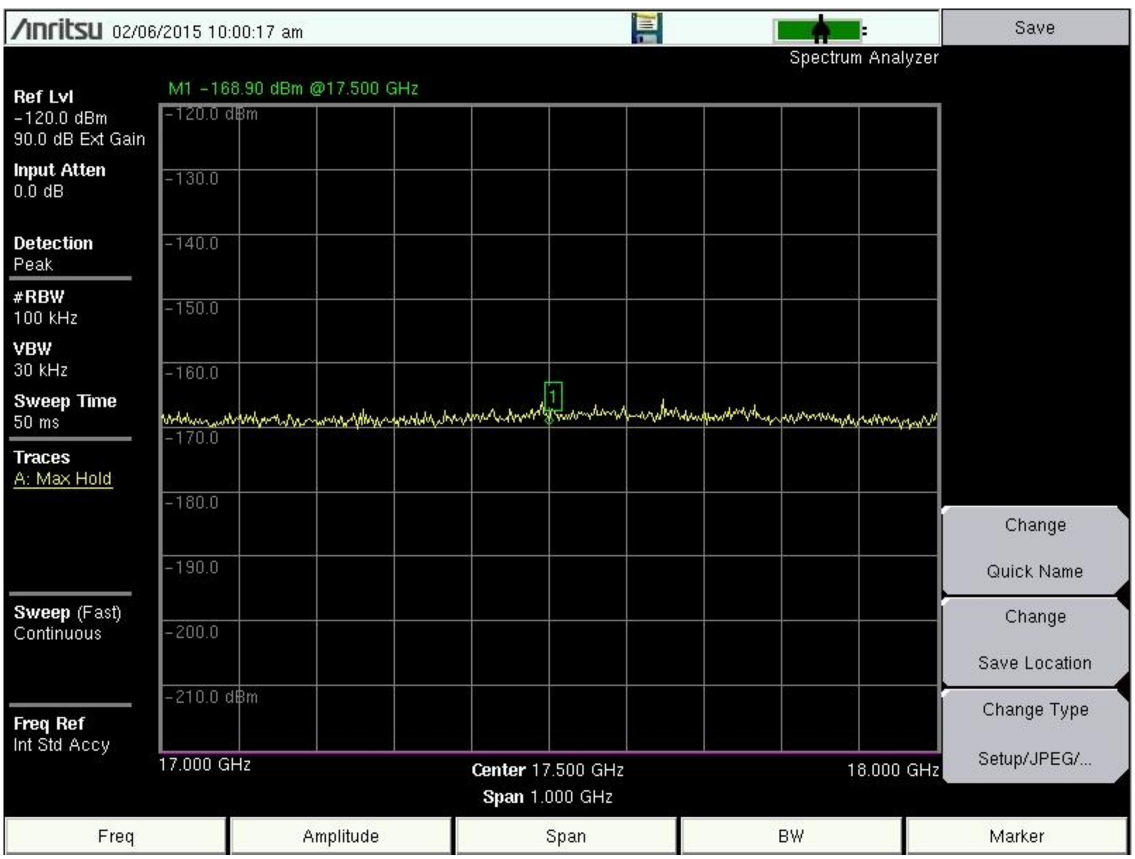

Figure 3.1-3 (D) Spectrum Photos 17-18 GHz 100 KHz Res BW Horizontal Pol Worst Case

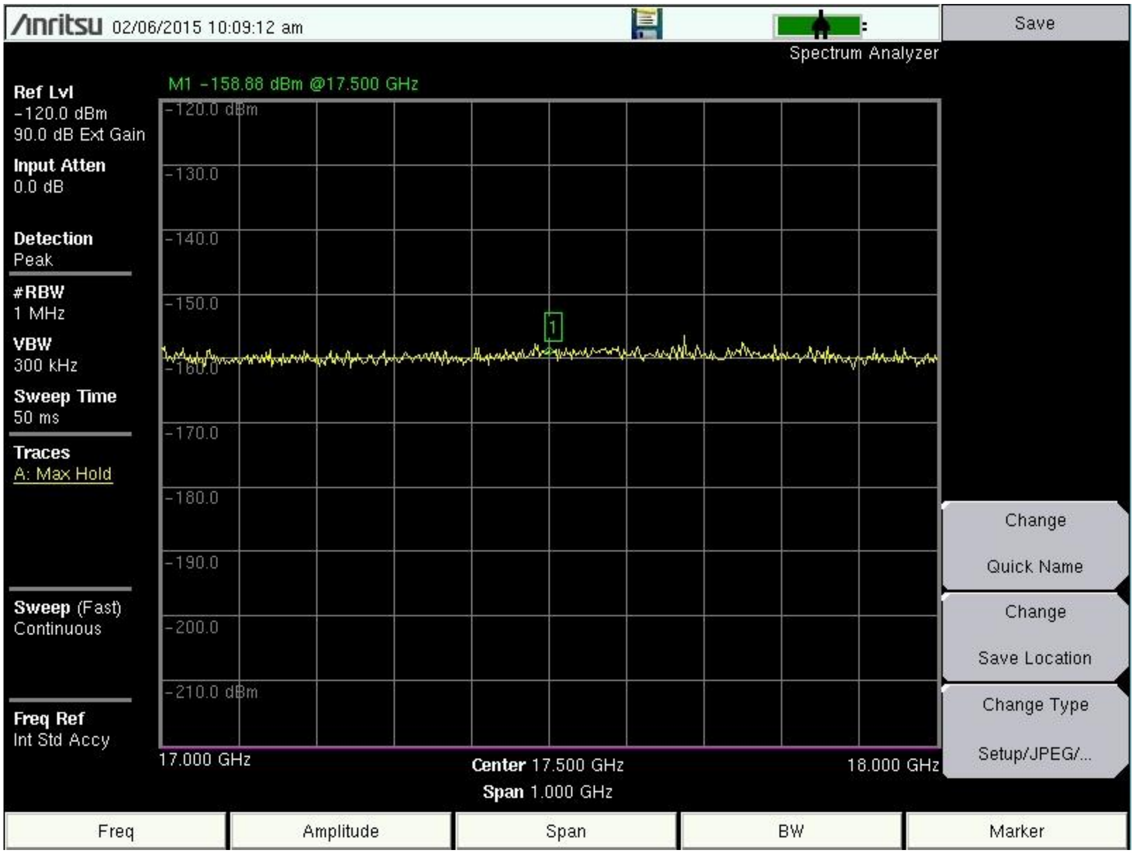

Figure 3.1-3 (E) Spectrum Photos 17-18 GHz 1MHz Res BW Vertical Pol 360^0

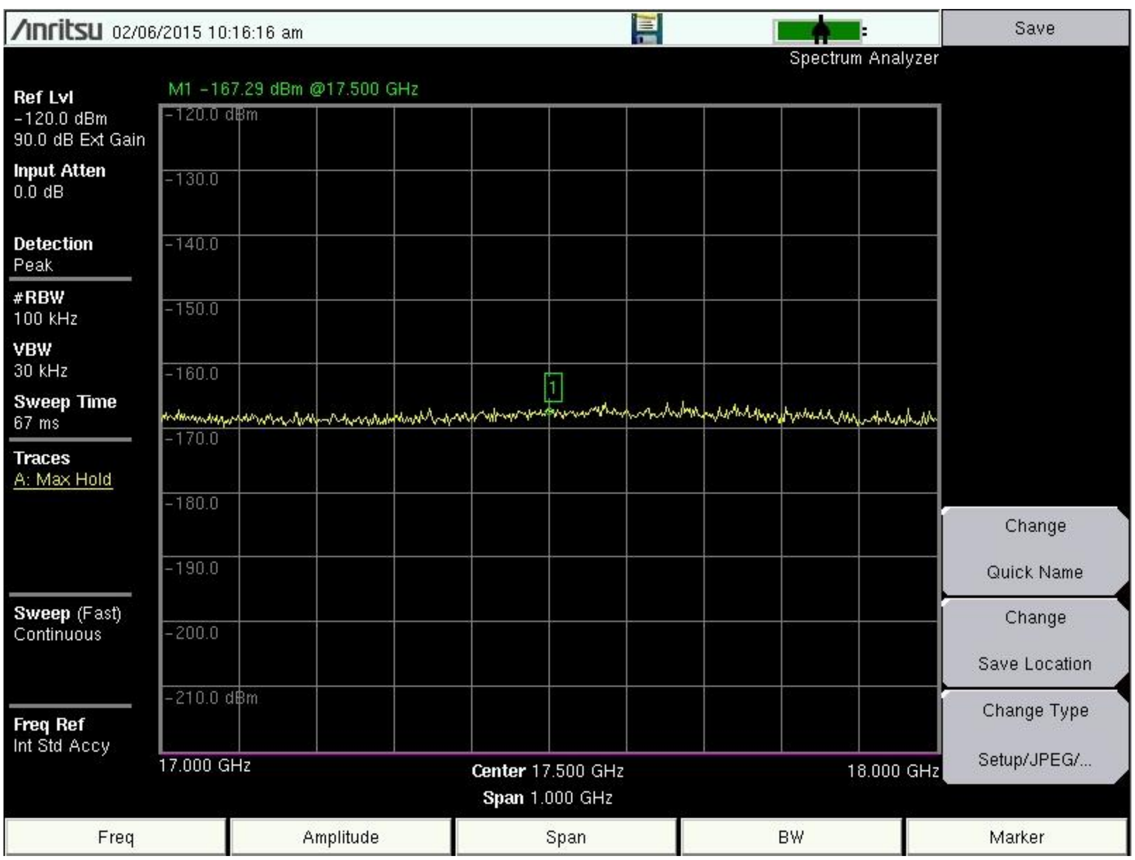

Figure 3.1-3 (F) Spectrum Photos 17-18 GHz 100 KHz Res BW Vertical Pol 360^0

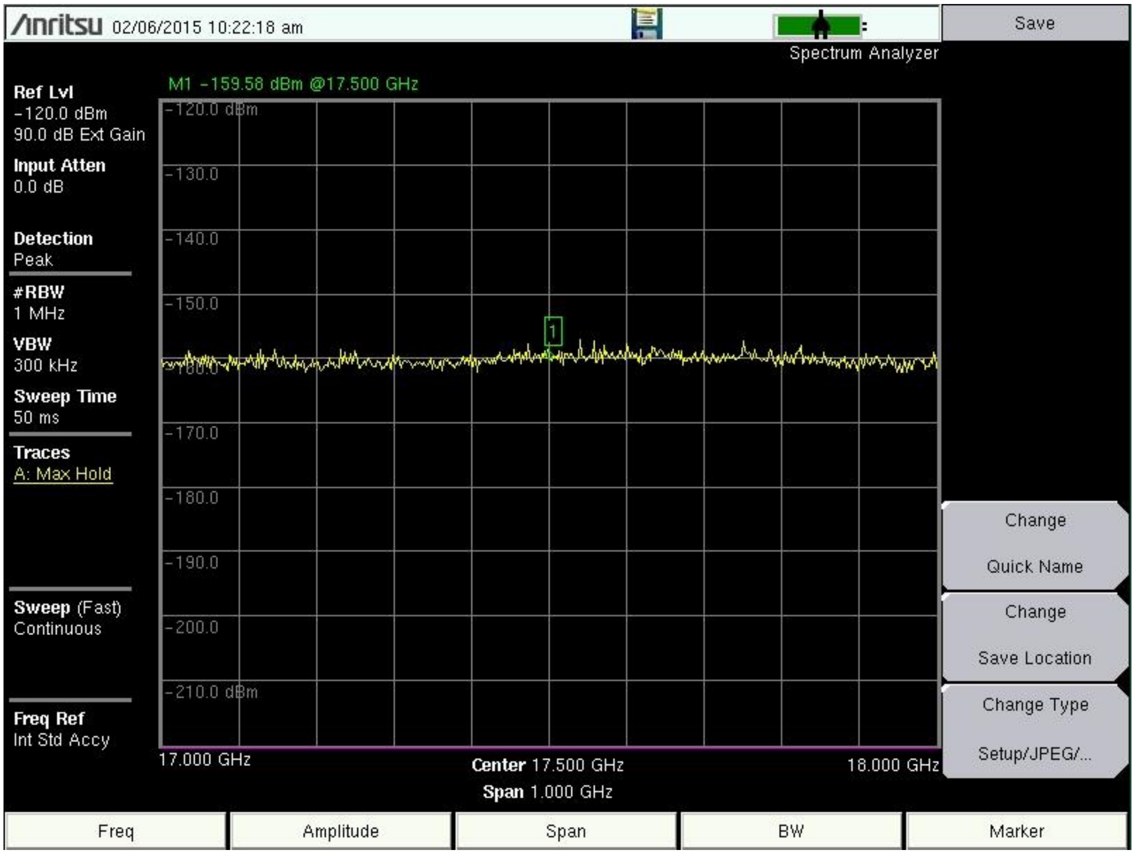

Figure 3.1-3 (G) Spectrum Photos 17-18 GHz 1 MHz Res BW Vertical Pol Worst Case

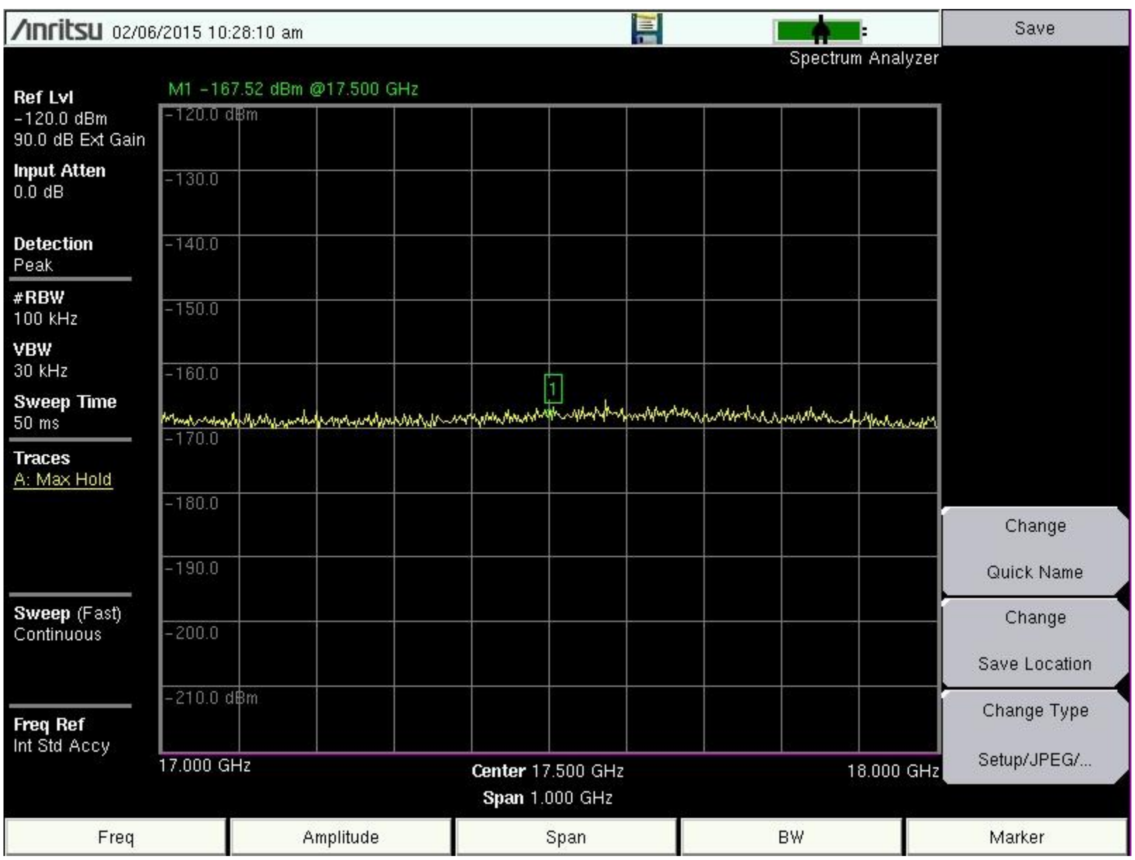

Figure 3.1-3 (H) Spectrum Photos 17-18 GHz 100 KHz Res BW Vertical Pol Worst Case

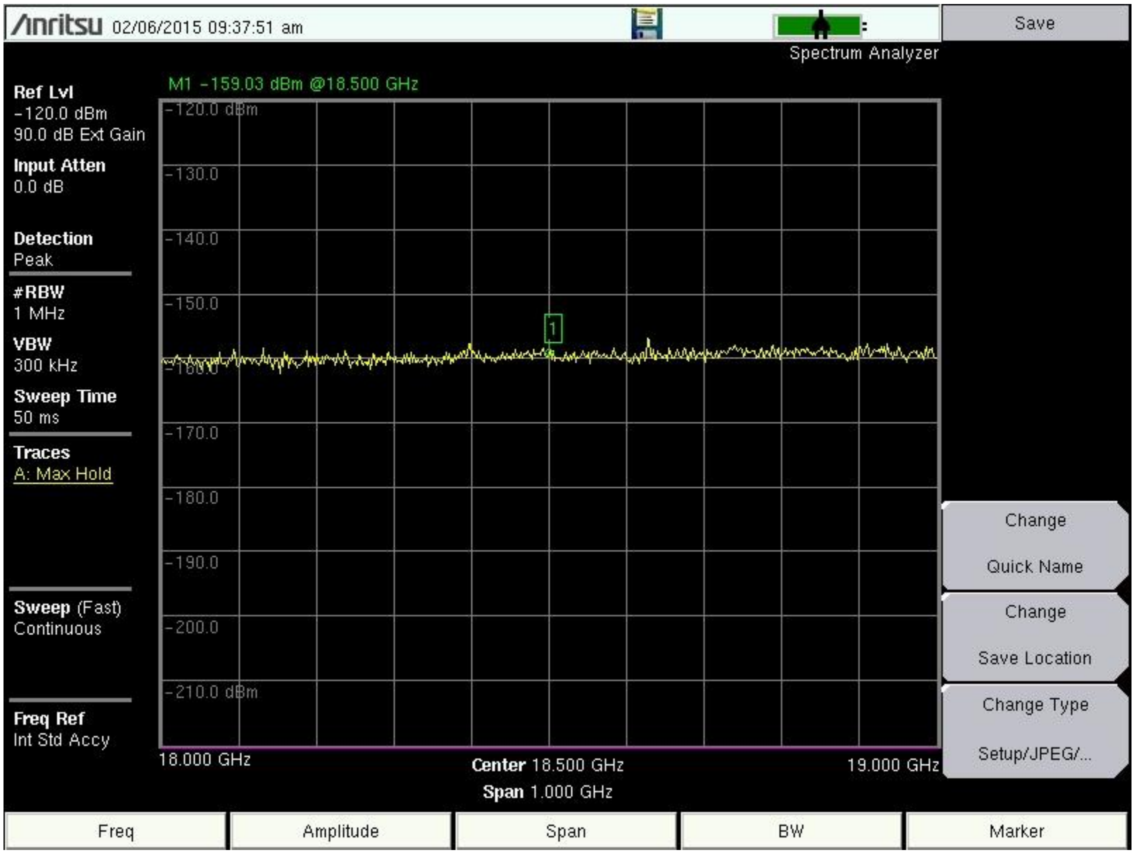

Figure 3.1-4 (A) Spectrum Photos 18-19 GHz 1MHz Res BW Horizontal Pol 360^0

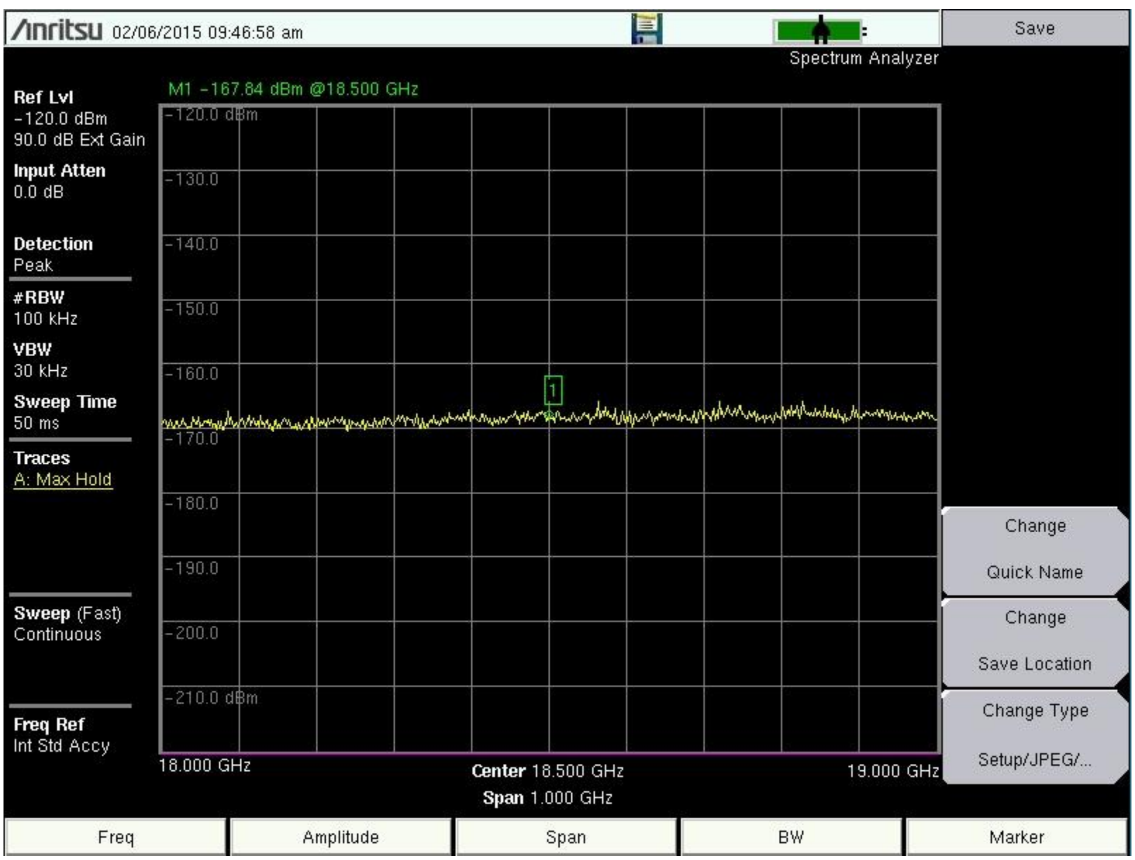

Figure 3.1-4 (B) Spectrum Photos 18-19 GHz 100 KHz Res BW Horizontal Pol 360^0

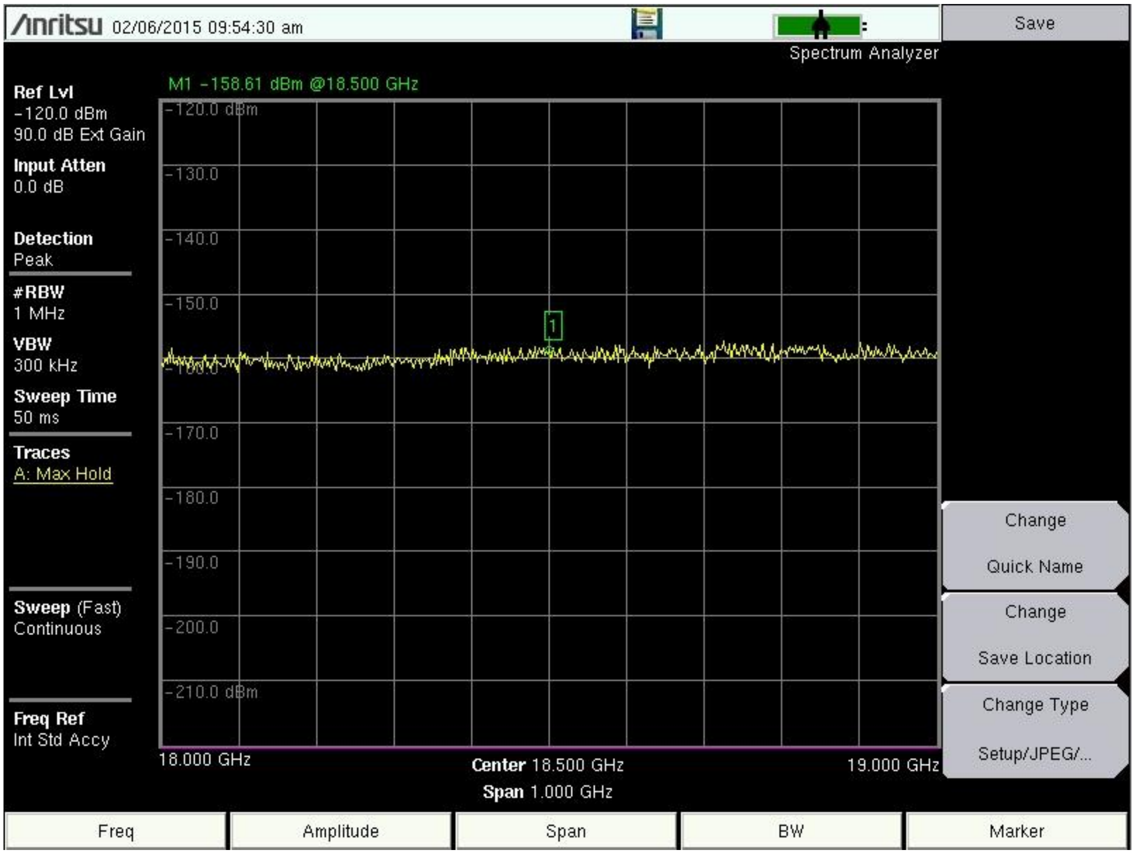

Figure 3.1-4 (C) Spectrum Photos 18-19 GHz 1MHz Res BW Horizontal Pol Worst Case

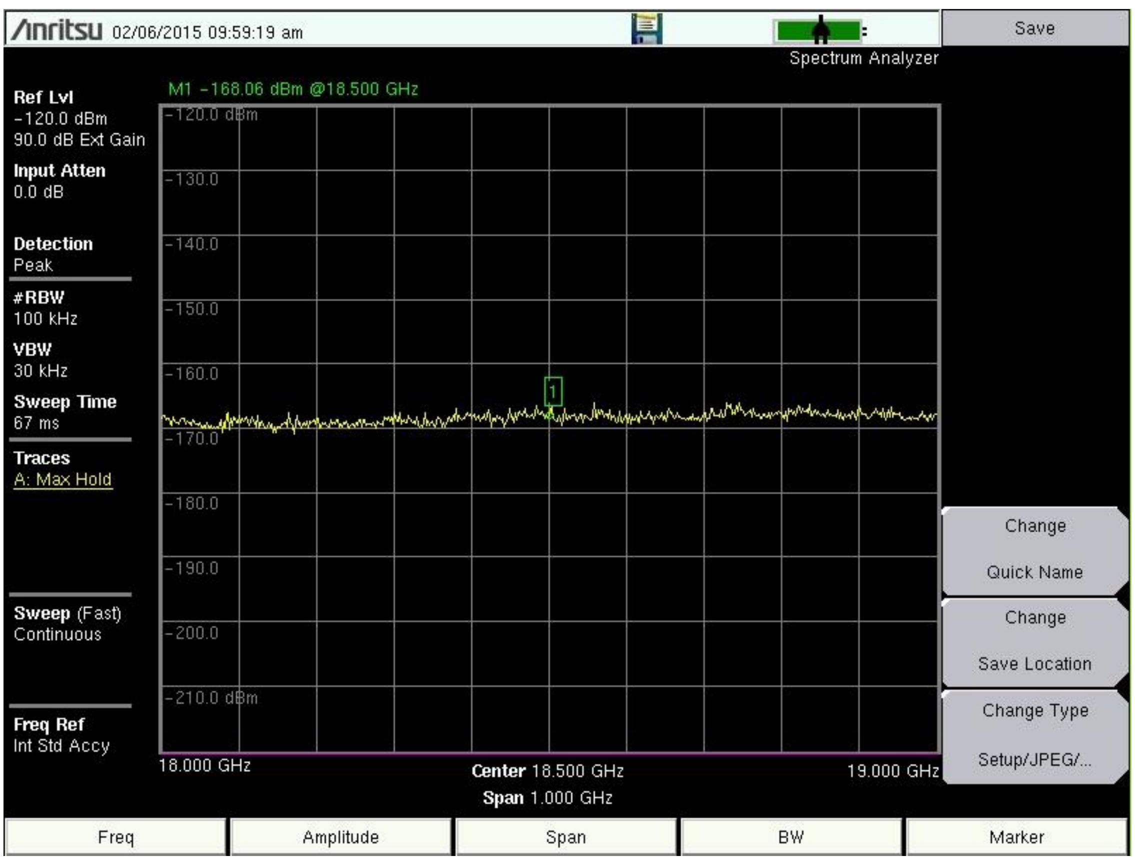

Figure 3.1-4 (D) Spectrum Photos 18-19 GHz 100 KHz Res BW Horizontal Pol Worst Case

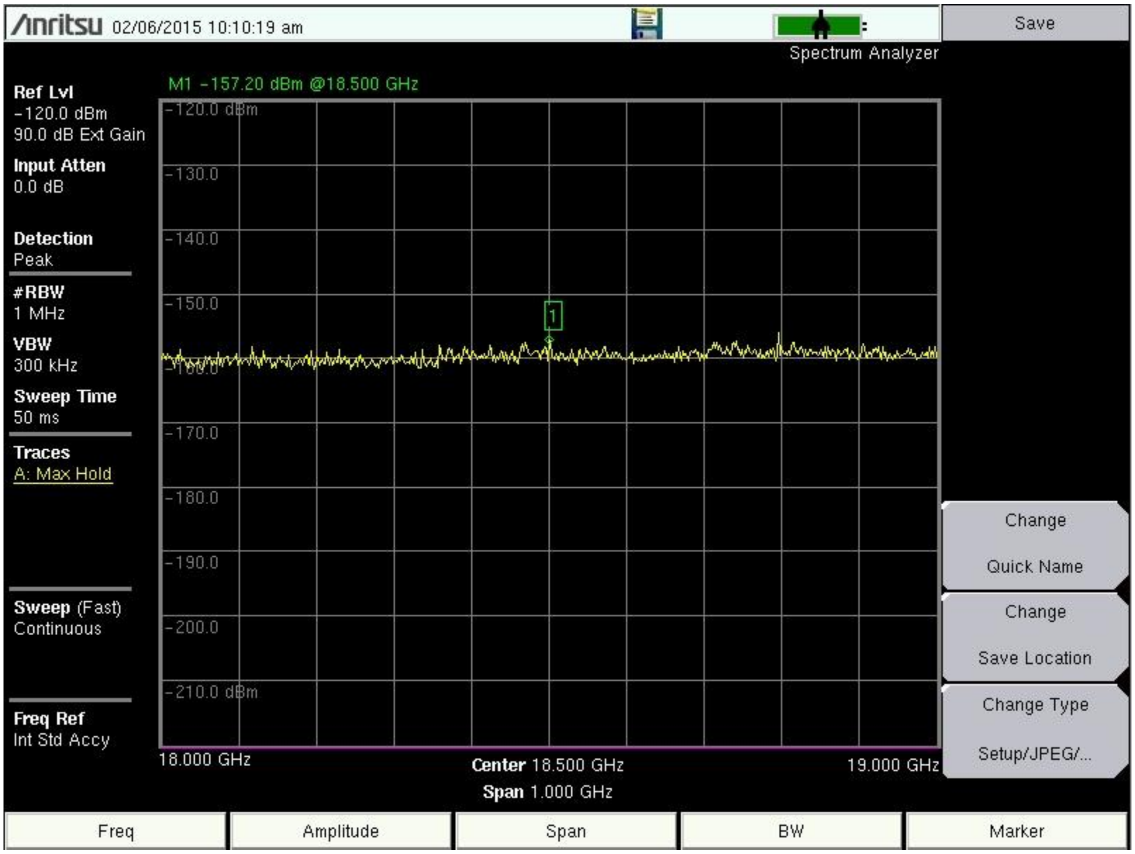

Figure 3.1-4 (E) Spectrum Photos 18-19 GHz 1MHz Res BW Vertical Pol 360^0

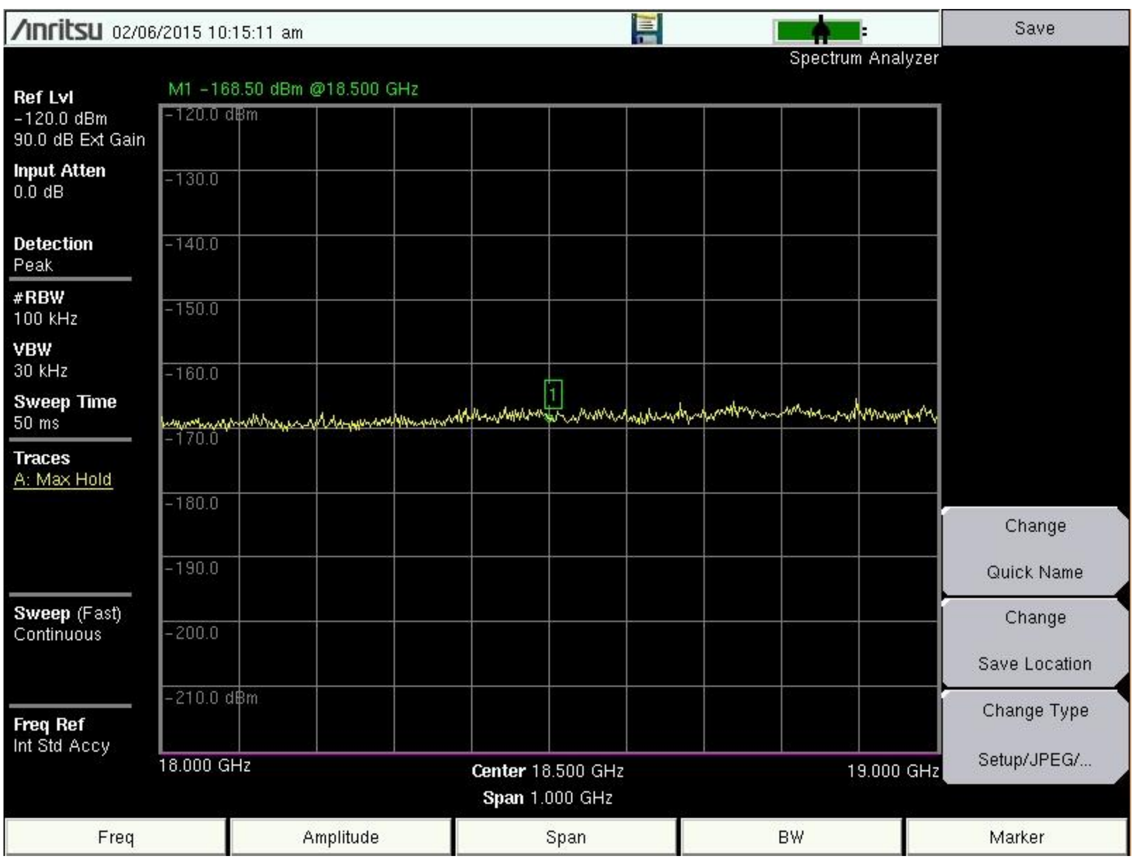

Figure 3.1-4 (F) Spectrum Photos 18-19 GHz 100 KHz Res BW Vertical Pol 360^0

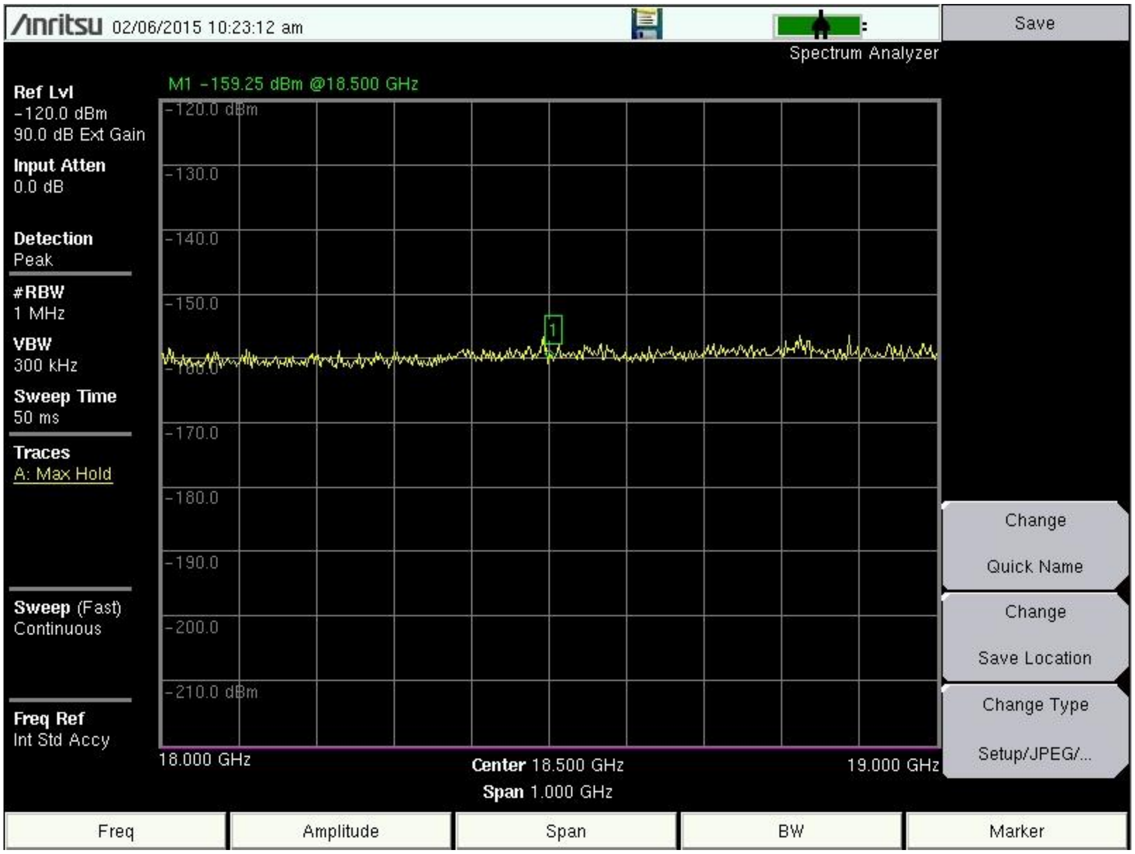

Figure 3.1-4 (G) Spectrum Photos 18-19 GHz 1 MHz Res BW Vertical Pol Worst Case

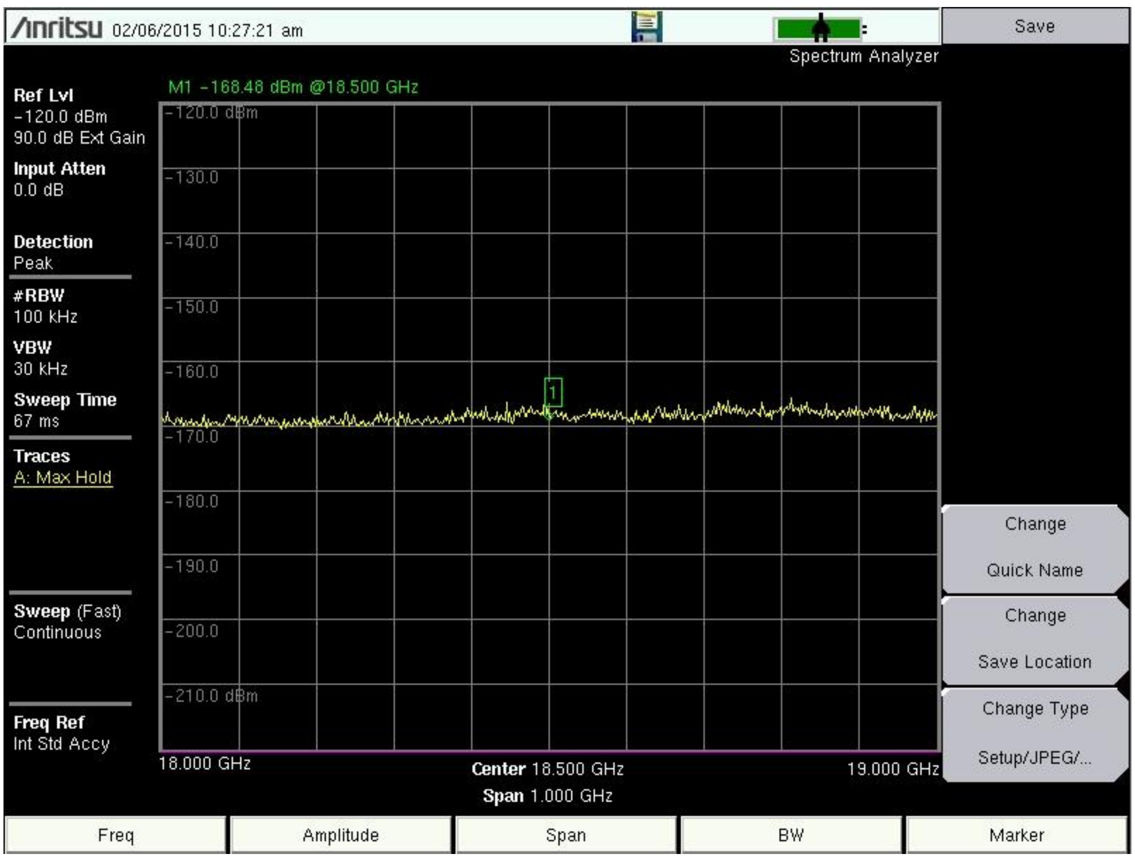

Figure 3.1-4 (H) Spectrum Photos 18-19 GHz 100 KHz Res BW Vertical Pol Worst Case

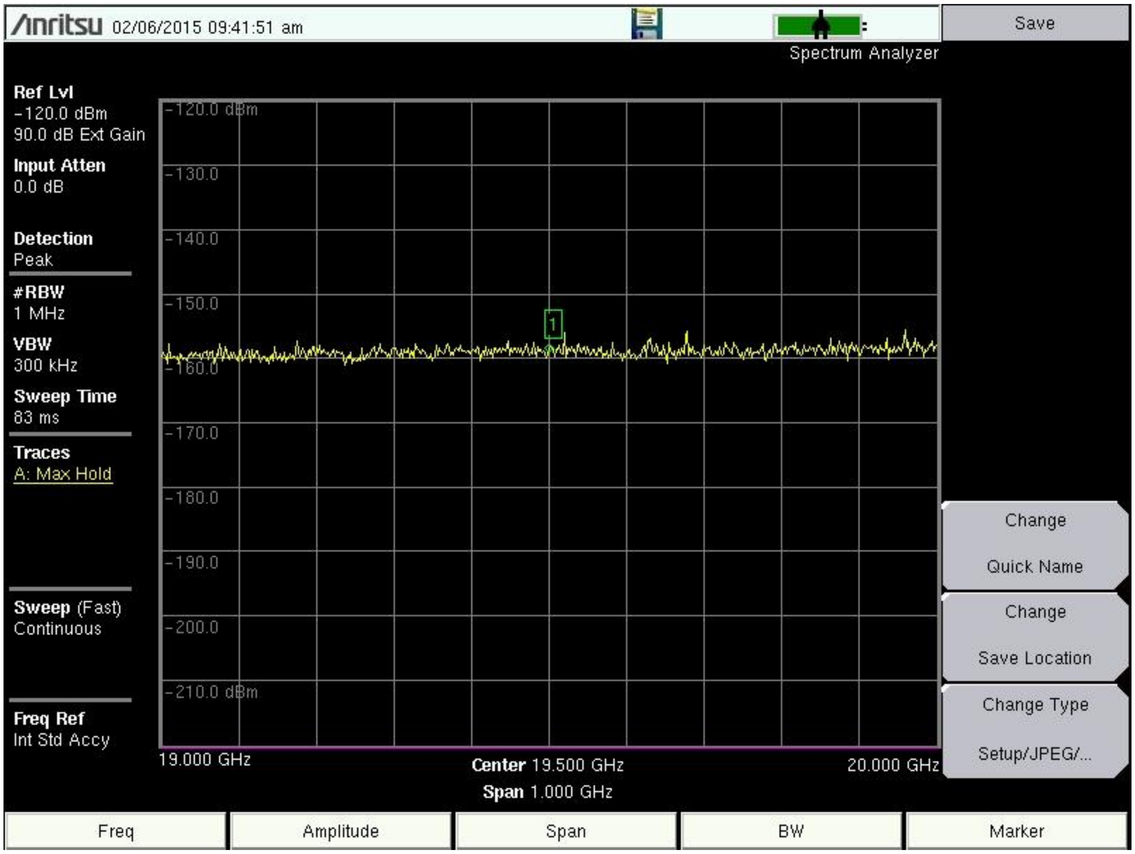

Figure 3.1-5 (A) Spectrum Photos 19-20 GHz 1MHz Res BW Horizontal Pol 360^0

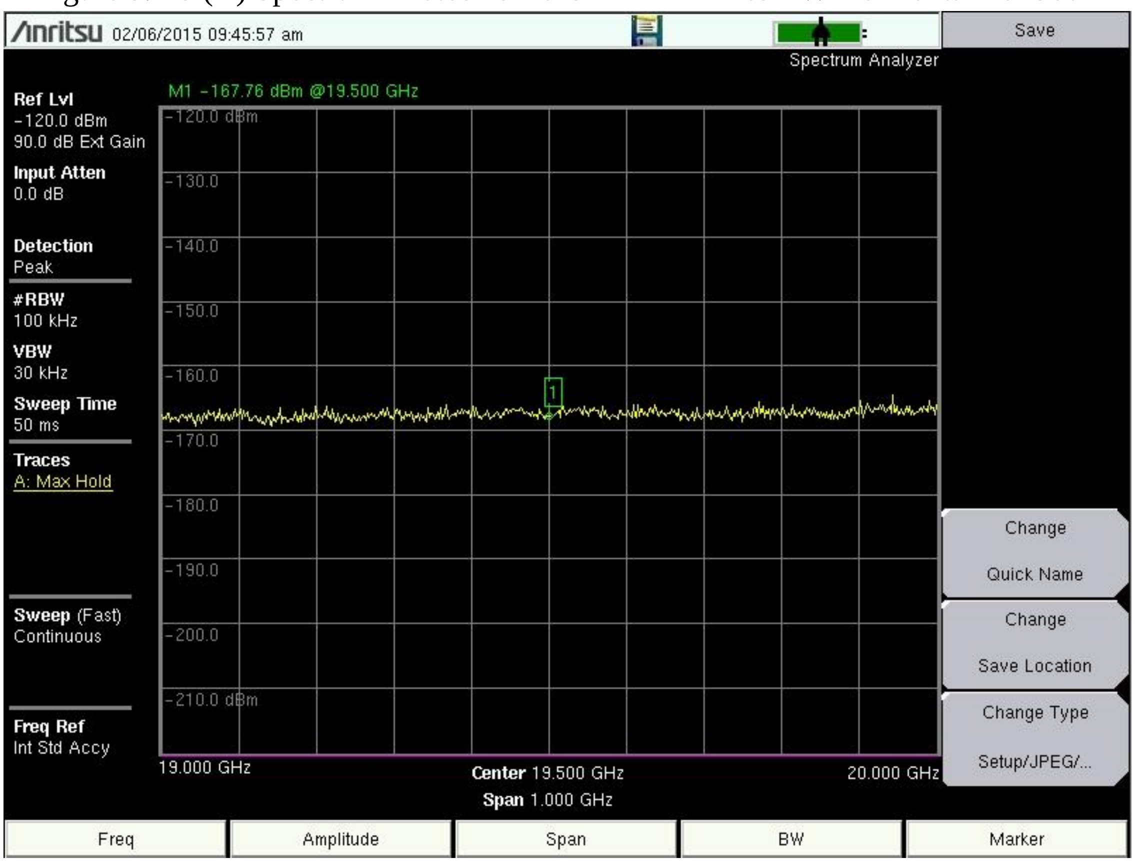

Figure 3.1-5 (B) Spectrum Photos 19-20 GHz 100 KHz Res BW Horizontal Pol 360^0

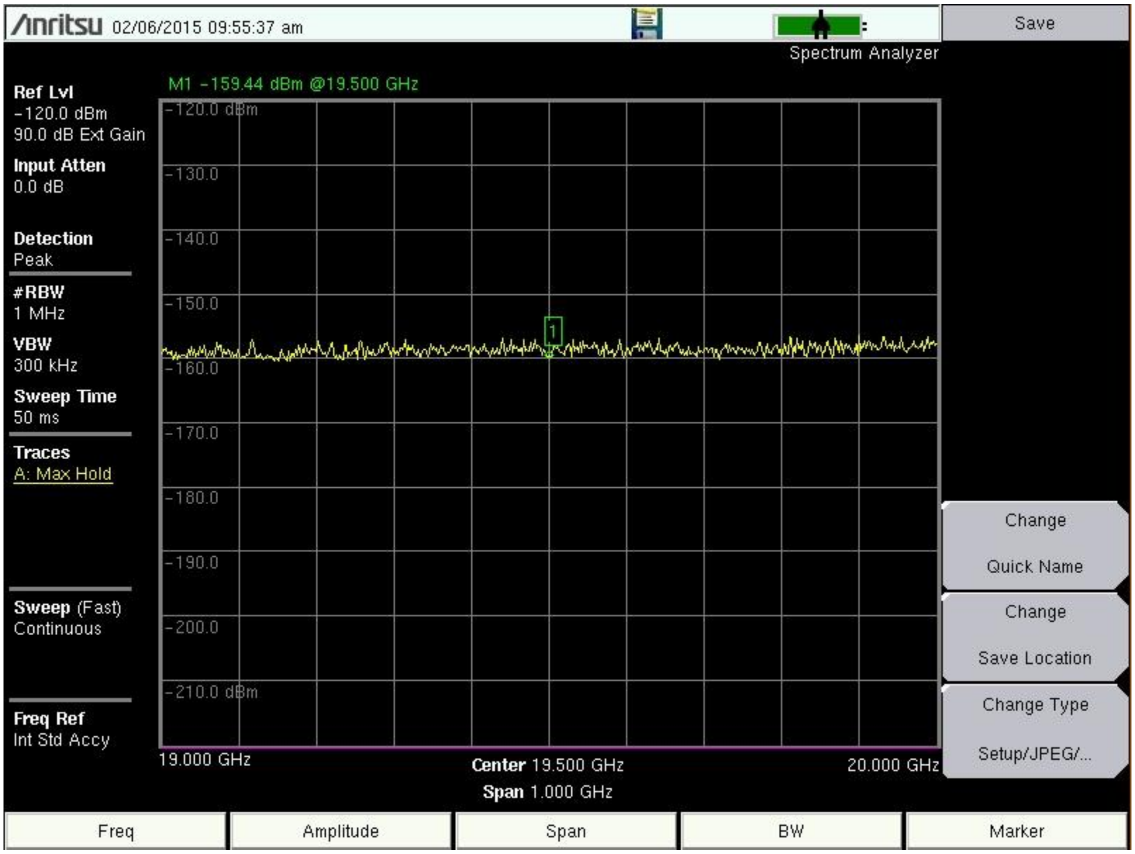

Figure 3.1-5 (C) Spectrum Photos 19-20 GHz 1MHz Res BW Horizontal Pol Worst Case

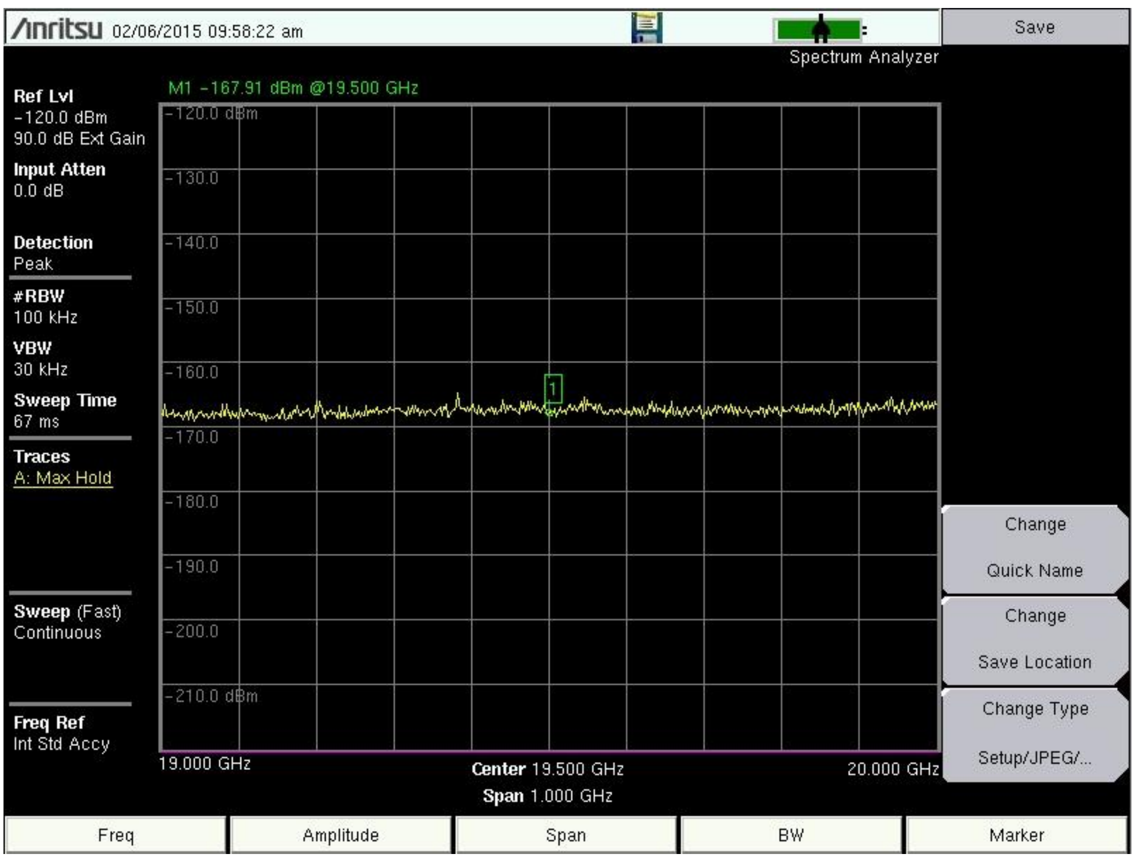

Figure 3.1-5 (D) Spectrum Photos 19-20 GHz 100 KHz Res BW Horizontal Pol Worst Case

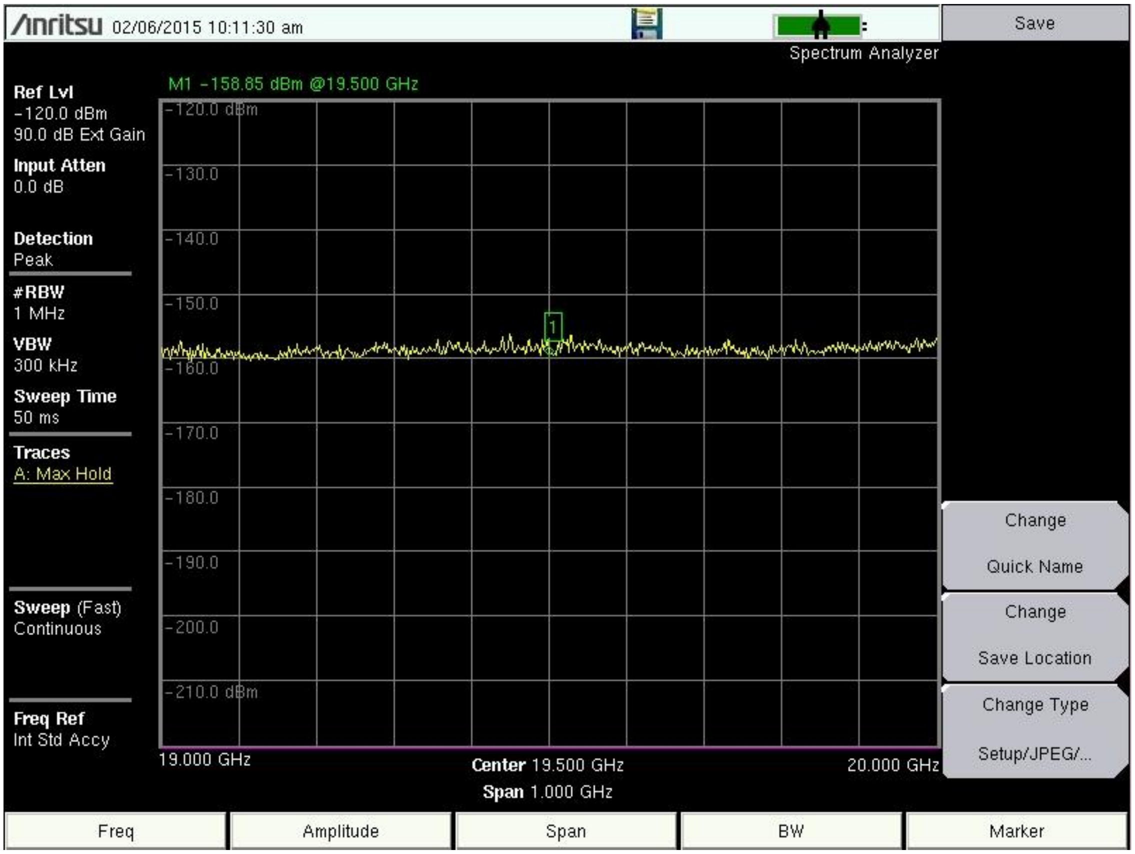

Figure 3.1-5 (E) Spectrum Photos 19-20 GHz 1MHz Res BW Vertical Pol 360^0

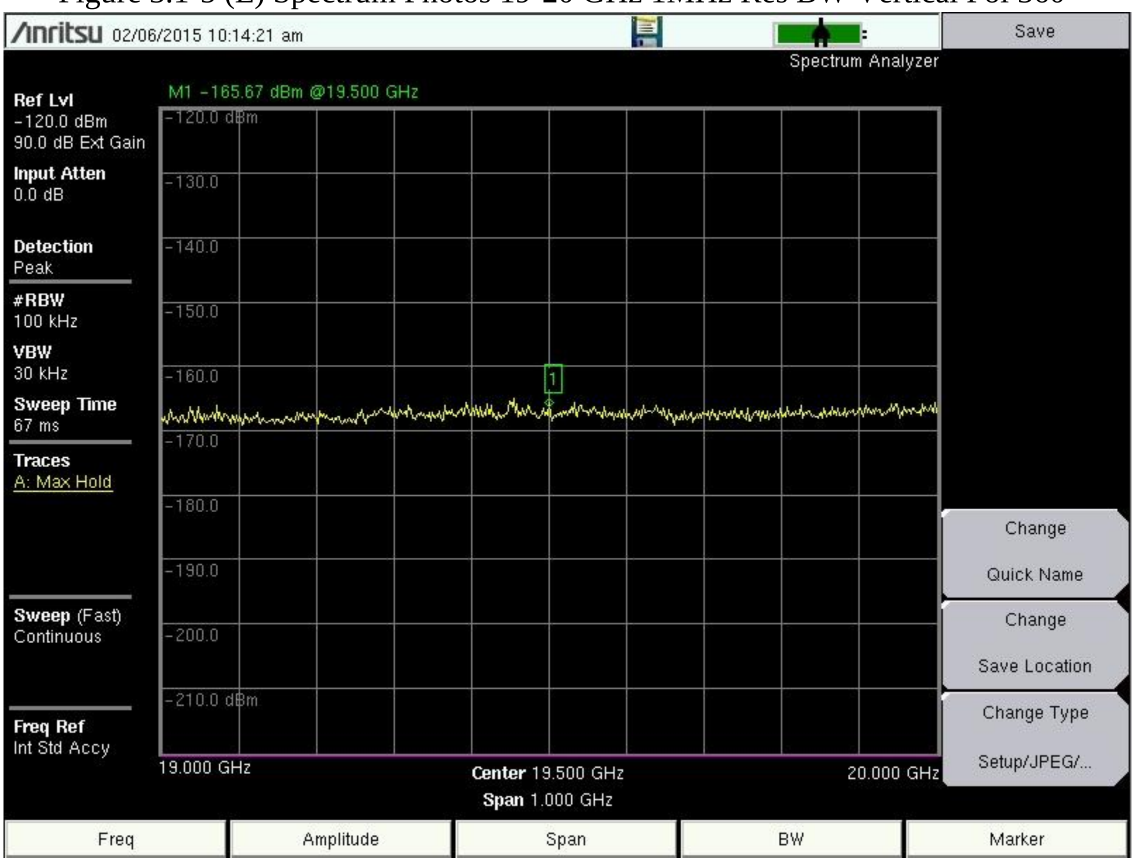

Figure 3.1-5 (F) Spectrum Photos 19-20 GHz 100 KHz Res BW Vertical Pol 360^0

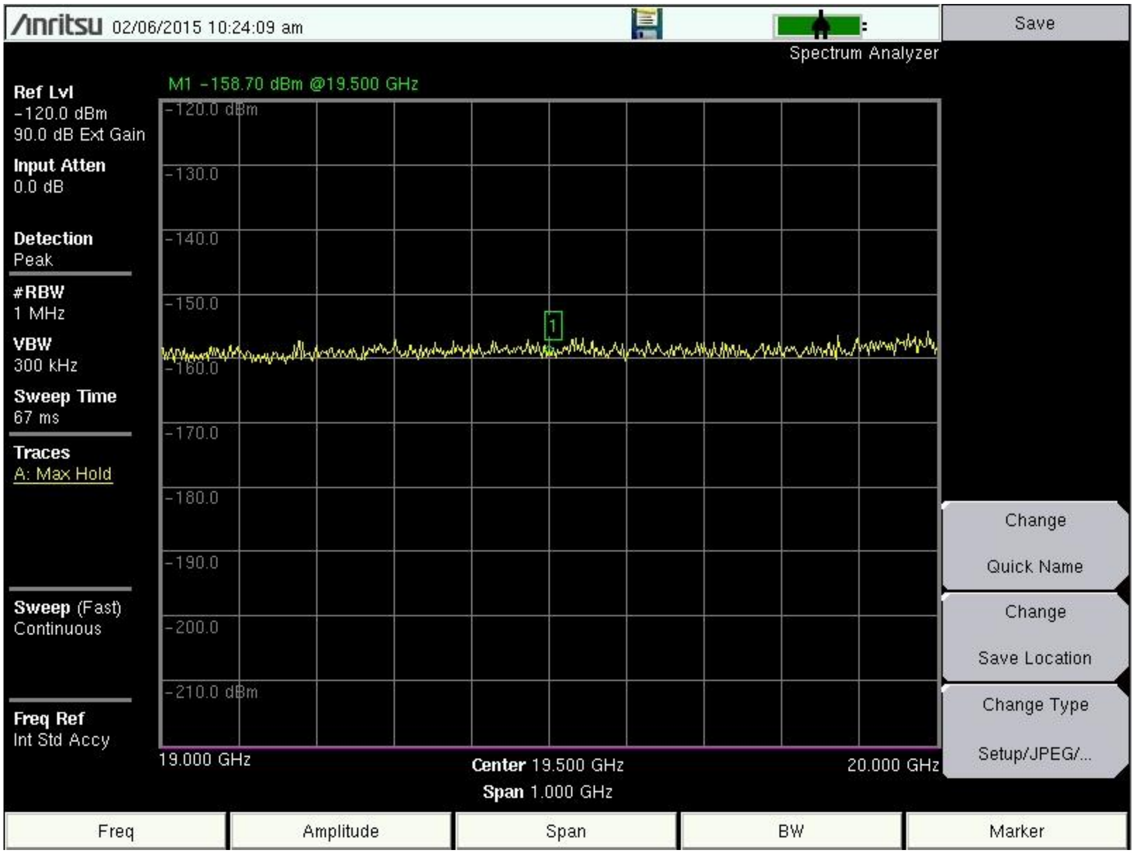

Figure 3.1-5 (G) Spectrum Photos 19-20 GHz 1 MHz Res BW Vertical Pol Worst Case

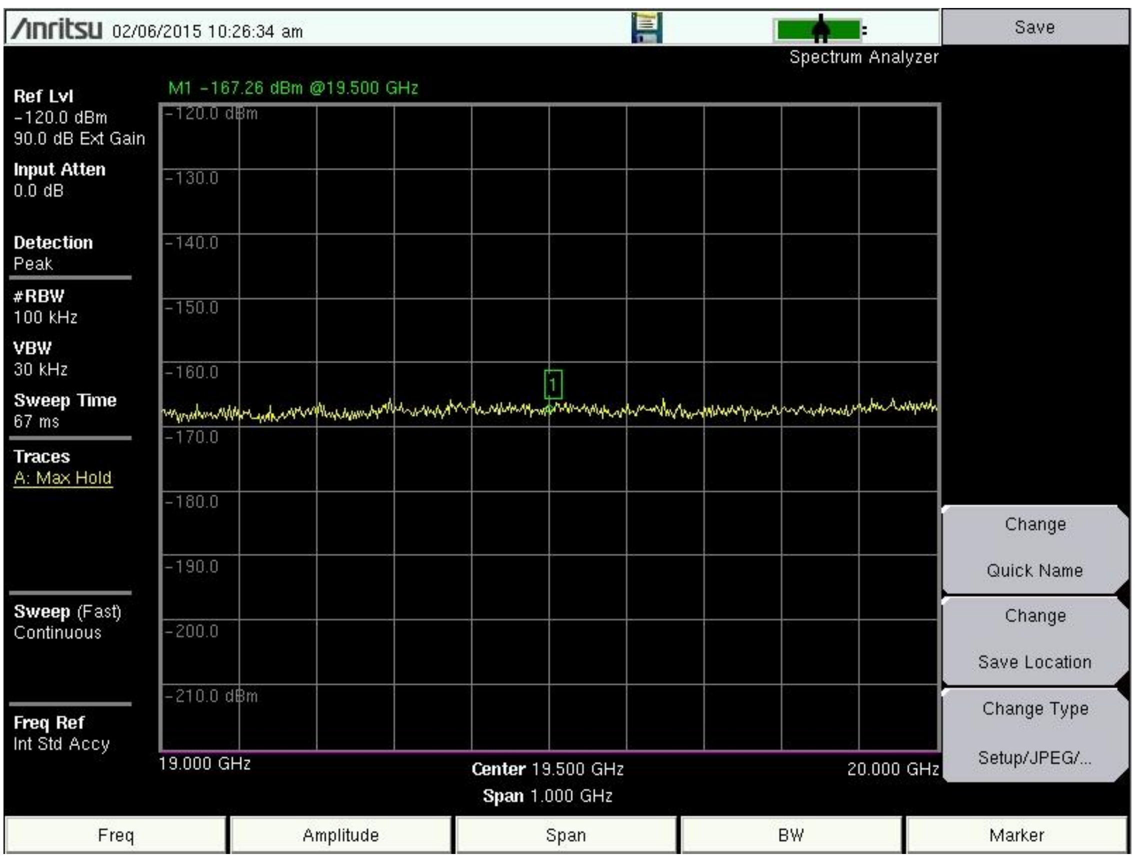

Figure 3.1-5 (H) Spectrum Photos 19-20 GHz 100 KHz Res BW Vertical Pol Worst Case

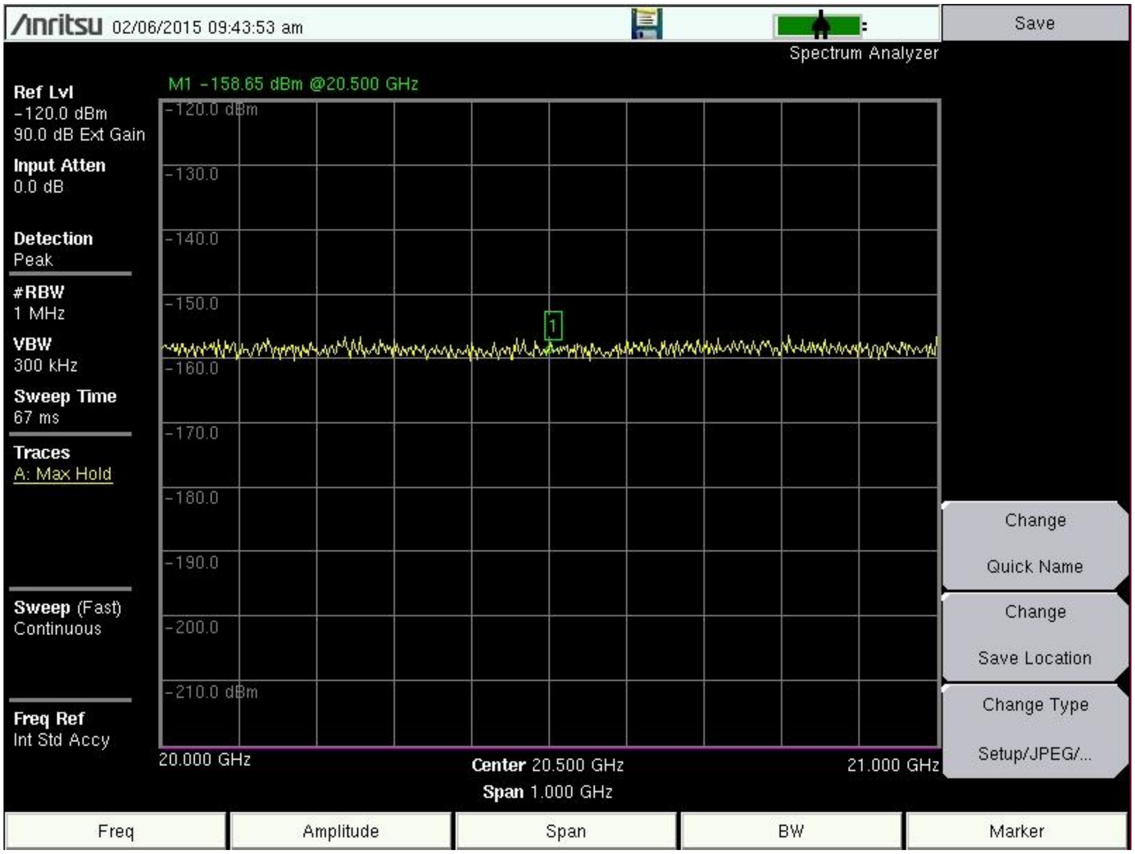

Figure 3.1-6 (A) Spectrum Photos 20-21 GHz 1MHz Res BW Horizontal Pol 360^0

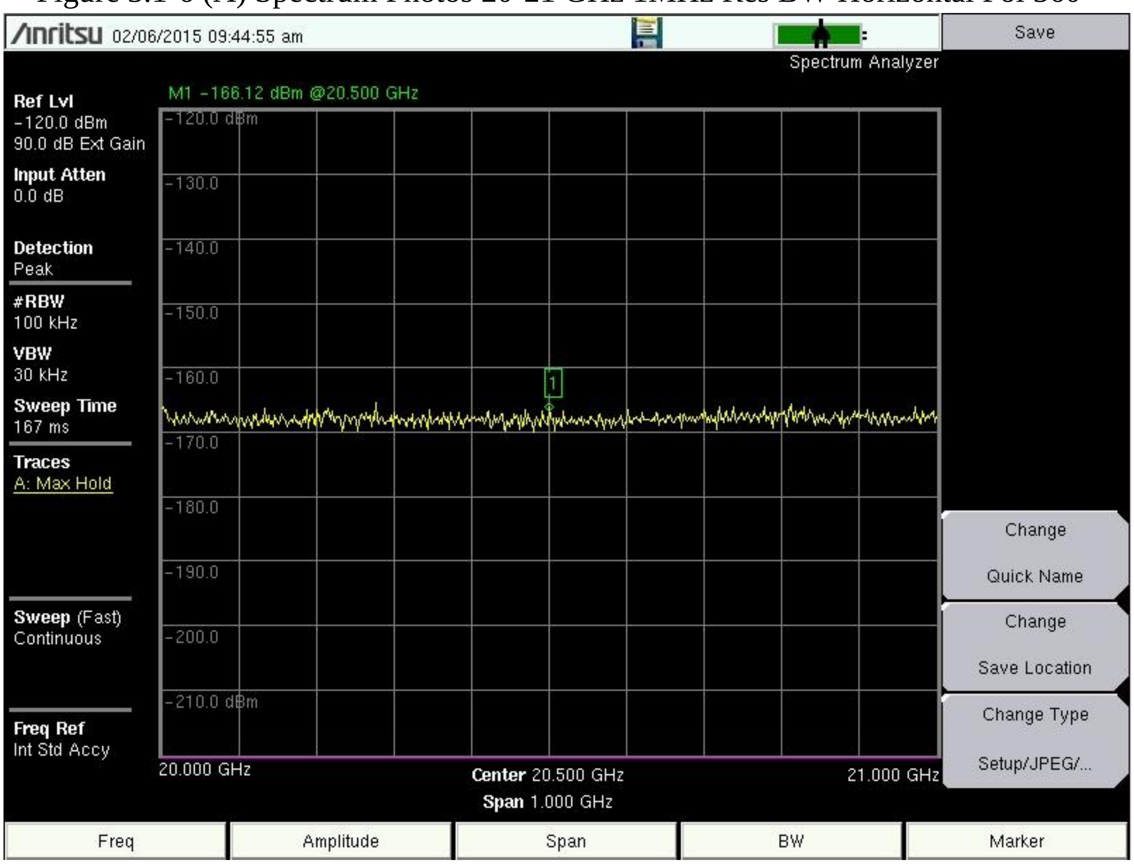

Figure 3.1-6 (B) Spectrum Photos 20-21 GHz 100 KHz Res BW Horizontal Pol 360^0

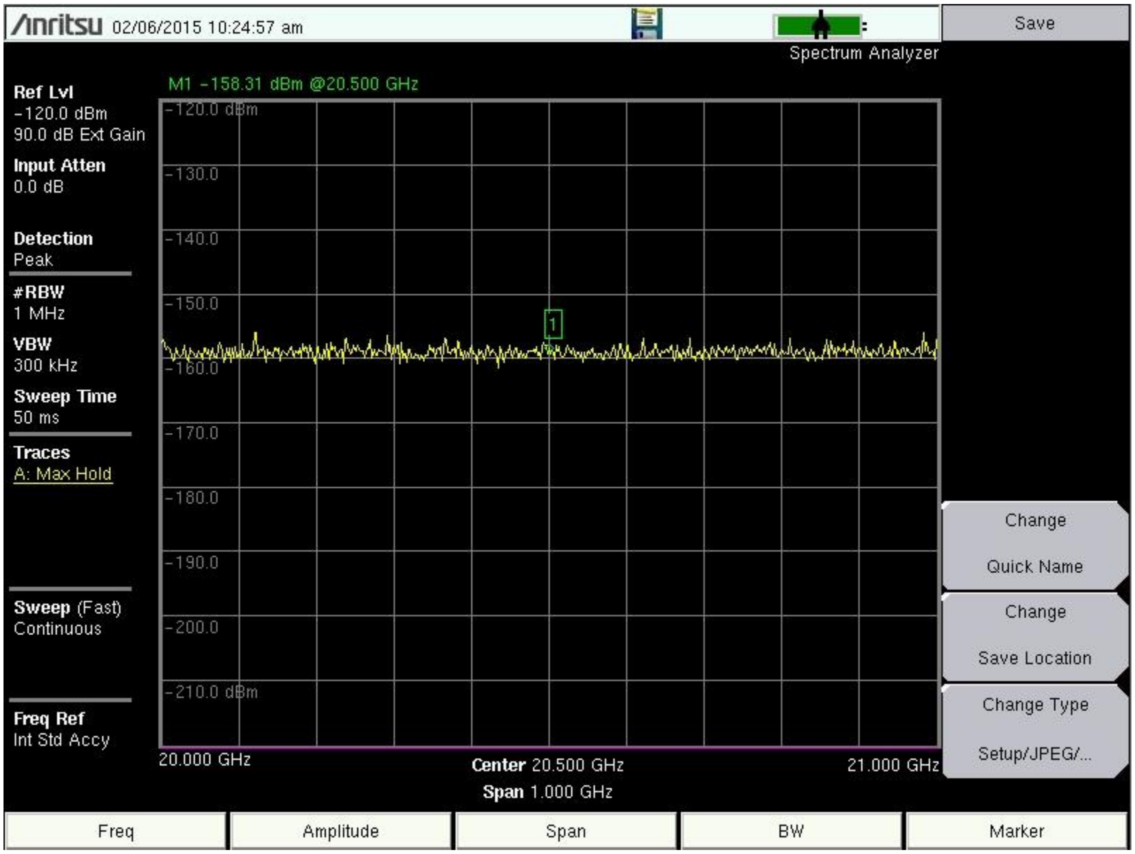

Figure 3.1-6 (C) Spectrum Photos 20-21 GHz 1MHz Res BW Horizontal Pol Worst Case

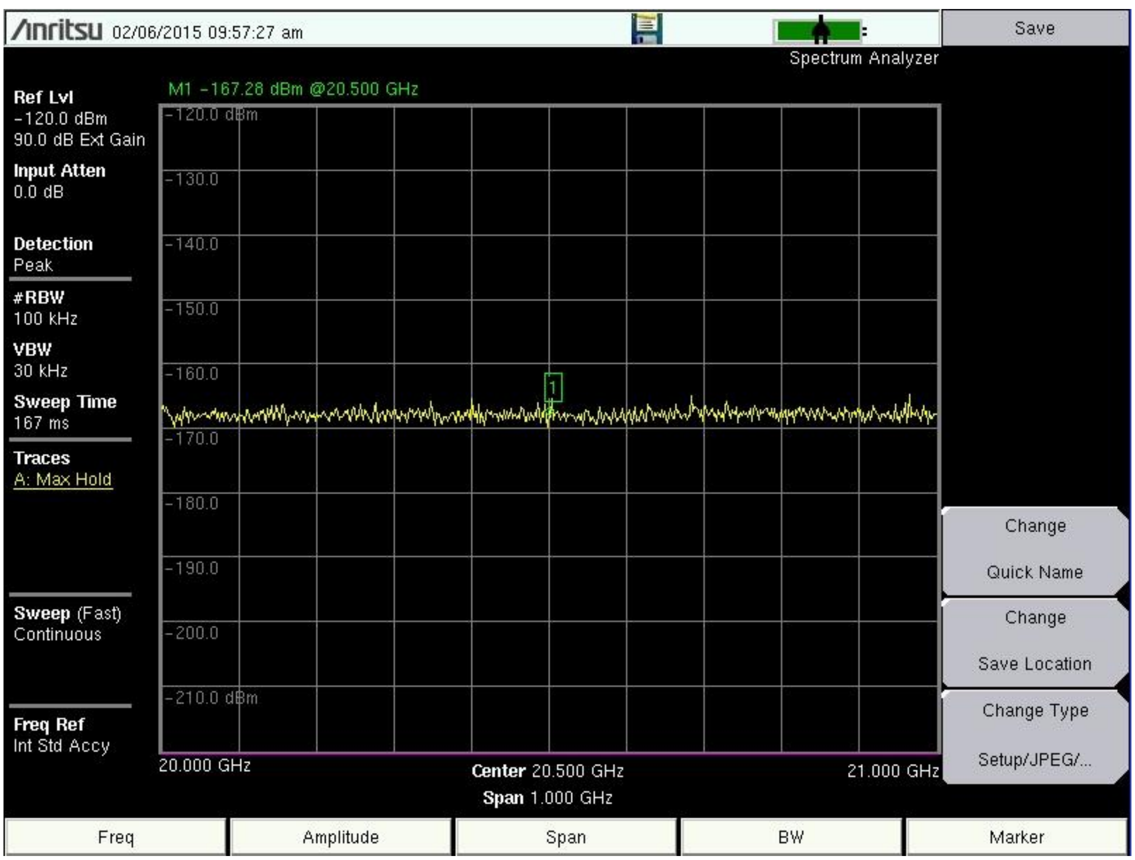

Figure 3.1-6 (D) Spectrum Photos 20-21 GHz 100 KHz Res BW Horizontal Pol Worst Case

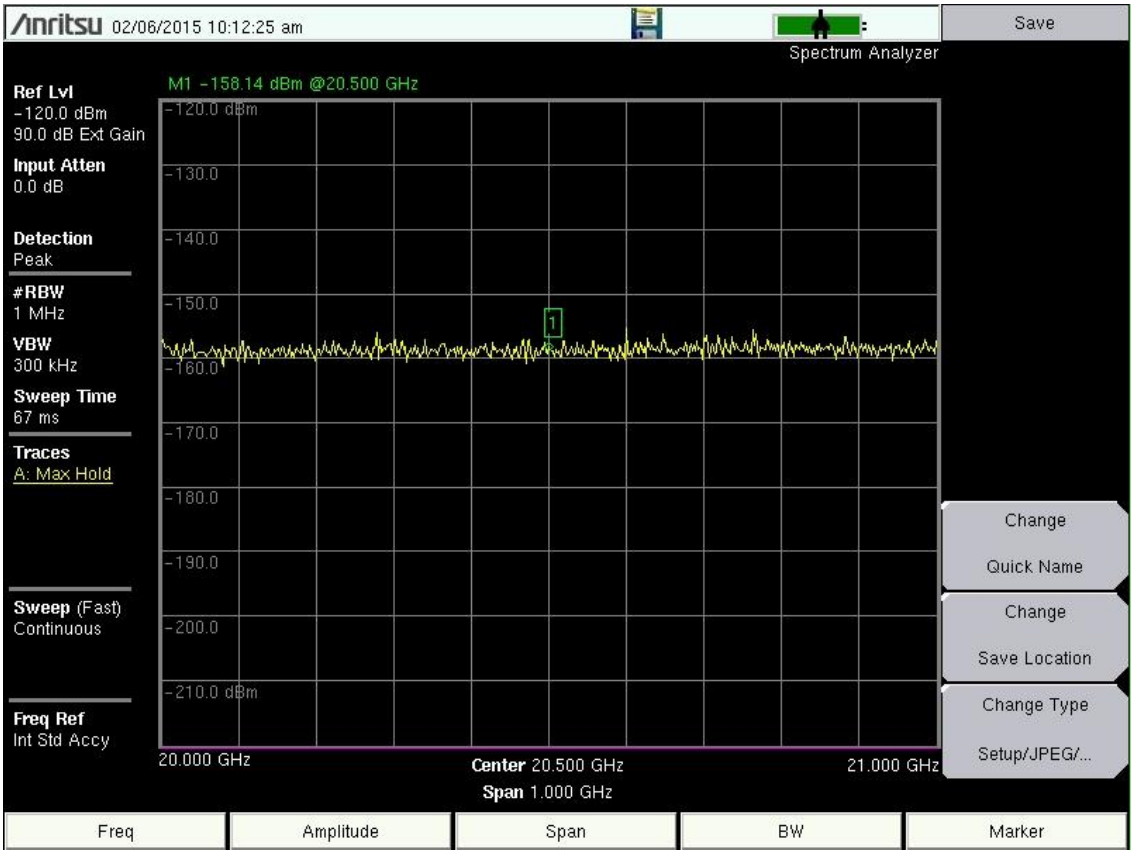

Figure 3.1-6 (E) Spectrum Photos 20-21 GHz 1MHz Res BW Vertical Pol 360^0

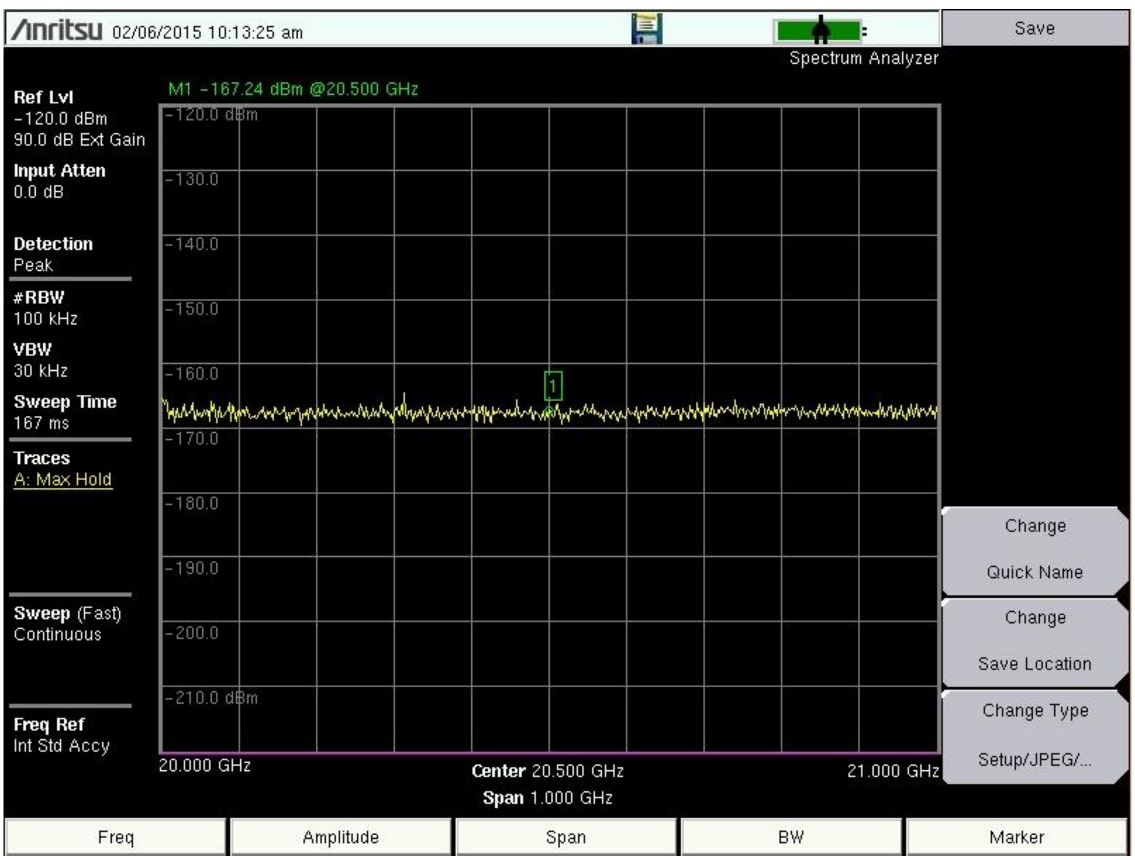

Figure 3.1-6 (F) Spectrum Photos 20-21 GHz 100 KHz Res BW Vertical Pol 360^0

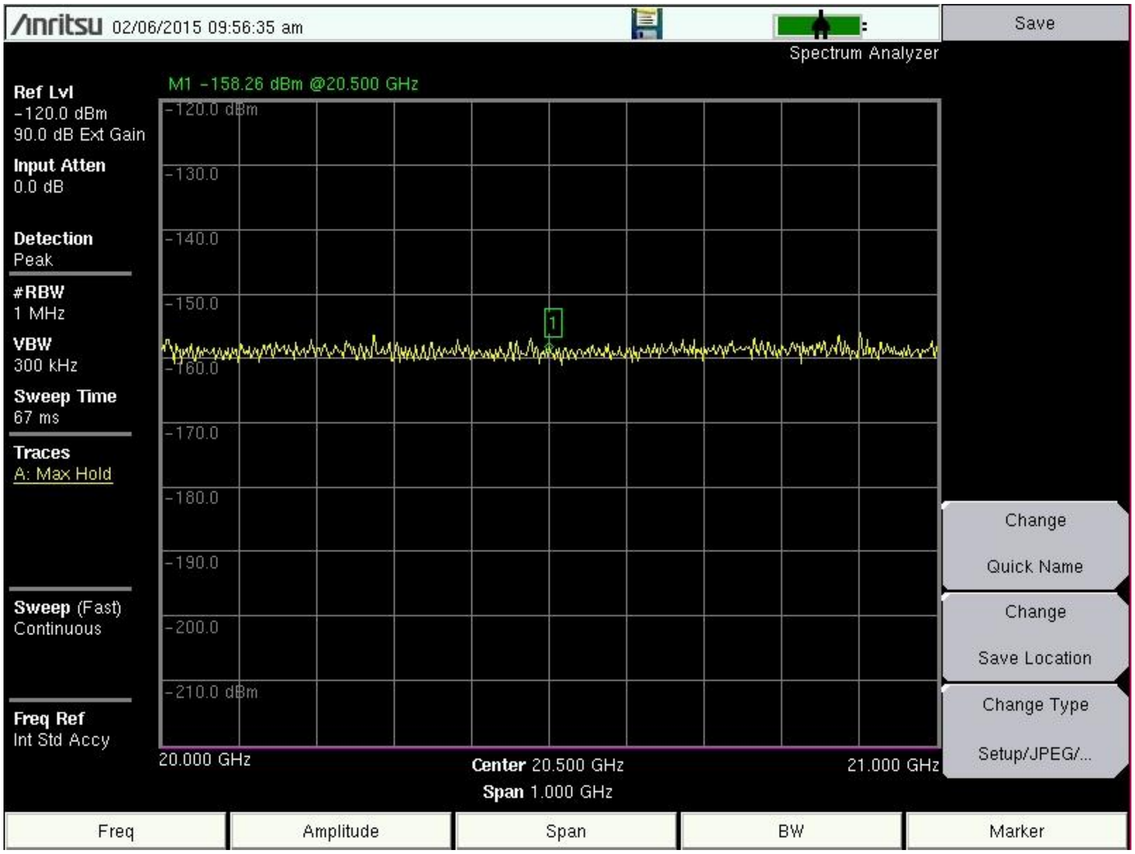

Figure 3.1-6 (G) Spectrum Photos 20-21 GHz 1 MHz Res BW Vertical Pol Worst Case

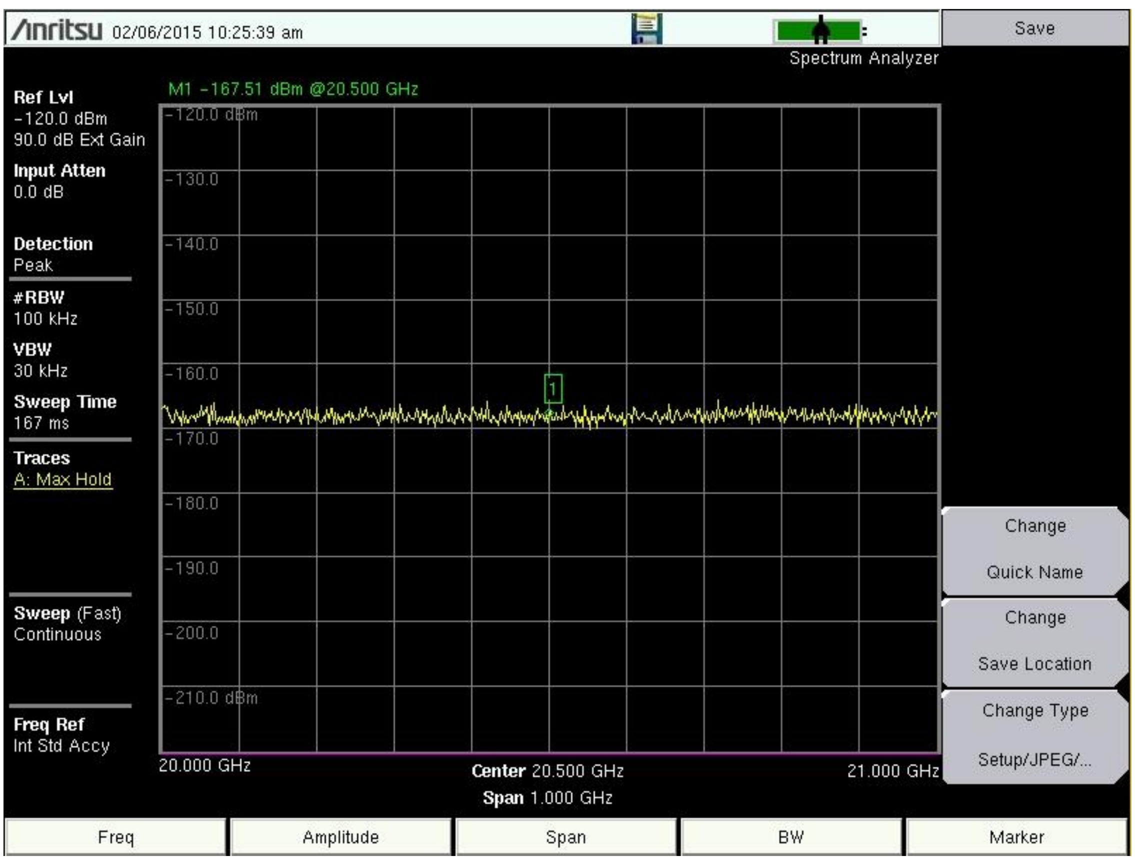

Figure 3.1-6 (H) Spectrum Photos 20-21 GHz 100 KHz Res BW Vertical Pol Worst Case

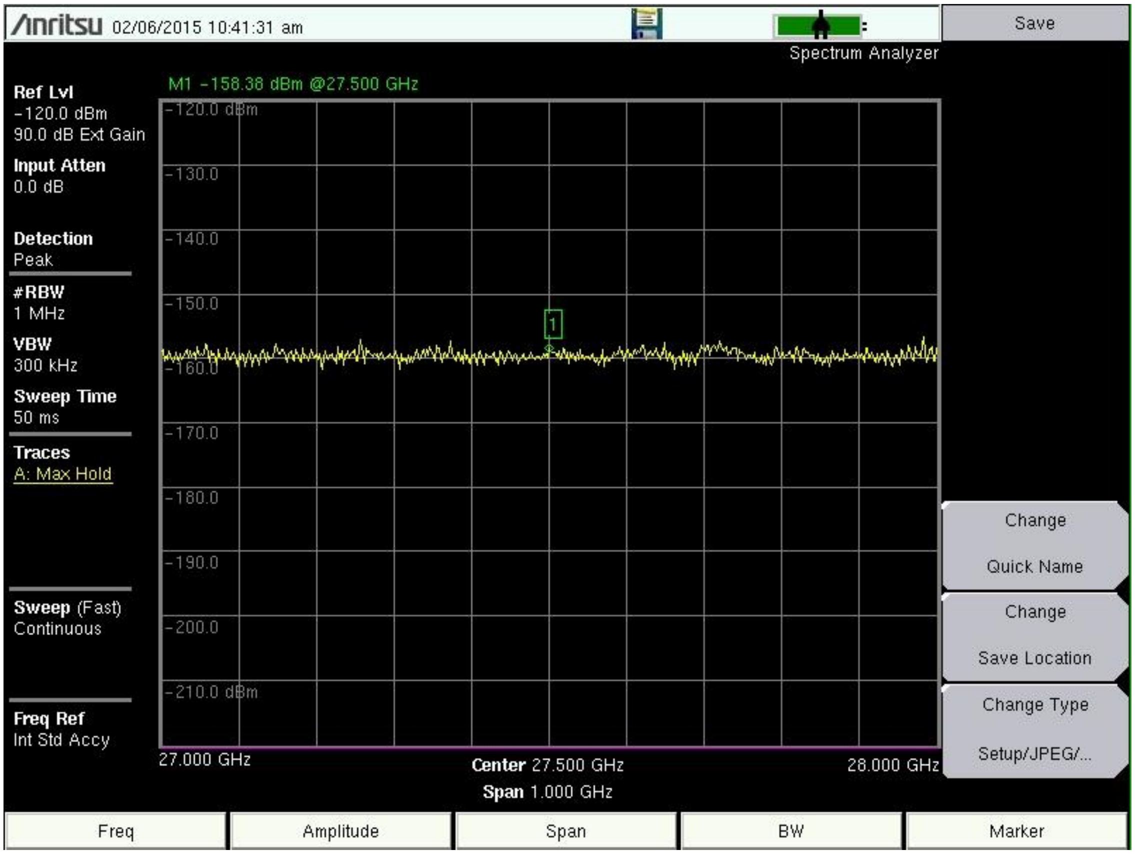

Figure 3.1-7 (A) Spectrum Photos 27-28 GHz 1MHz Res BW Horizontal Pol 360^0

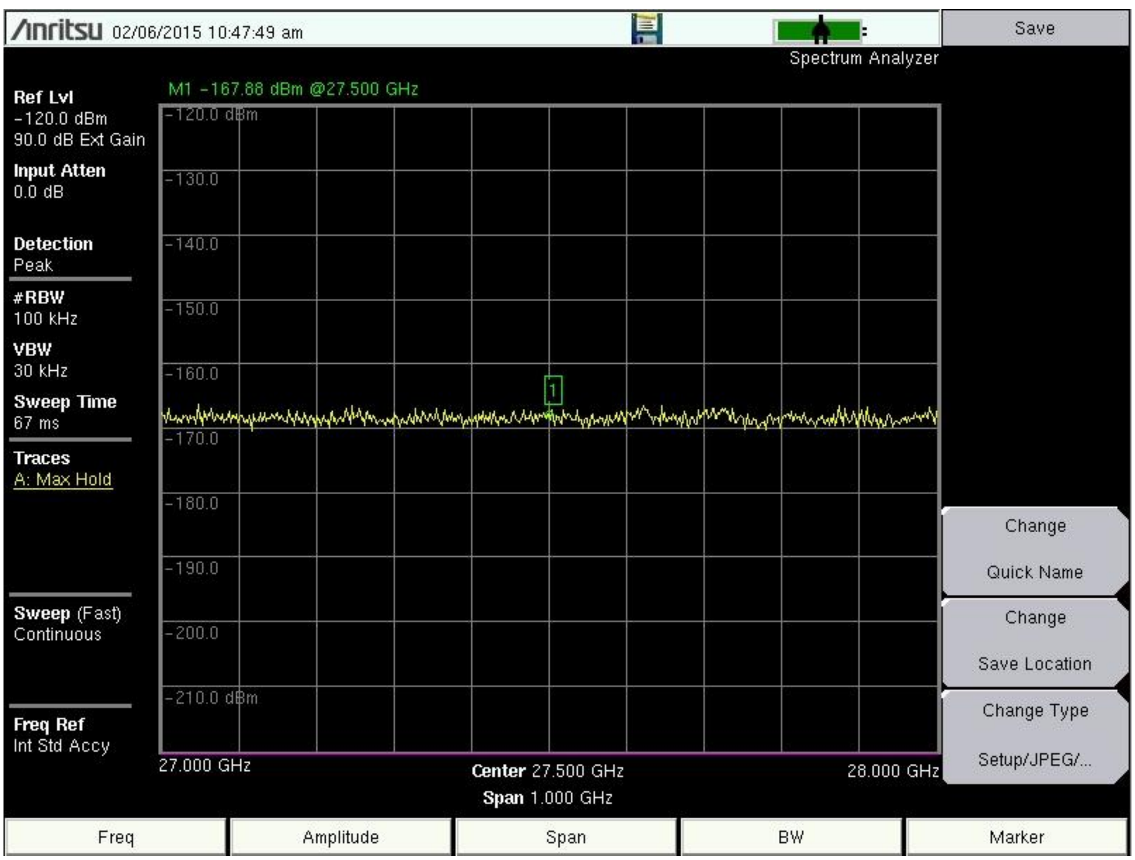

Figure 3.1-7 (B) Spectrum Photos 27-28 GHz 100 KHz Res BW Horizontal Pol 360^0

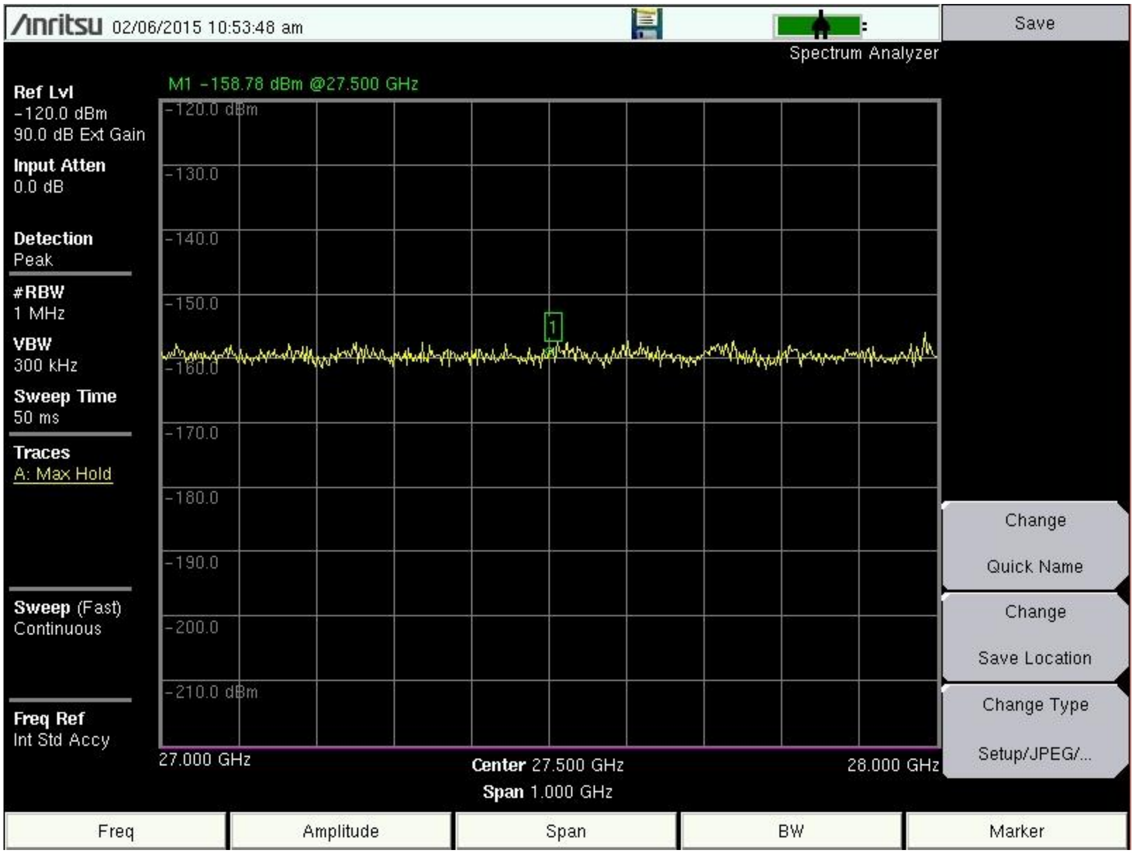

Figure 3.1-7 (C) Spectrum Photos 27-28 GHz 1MHz Res BW Vertical Pol 360^0

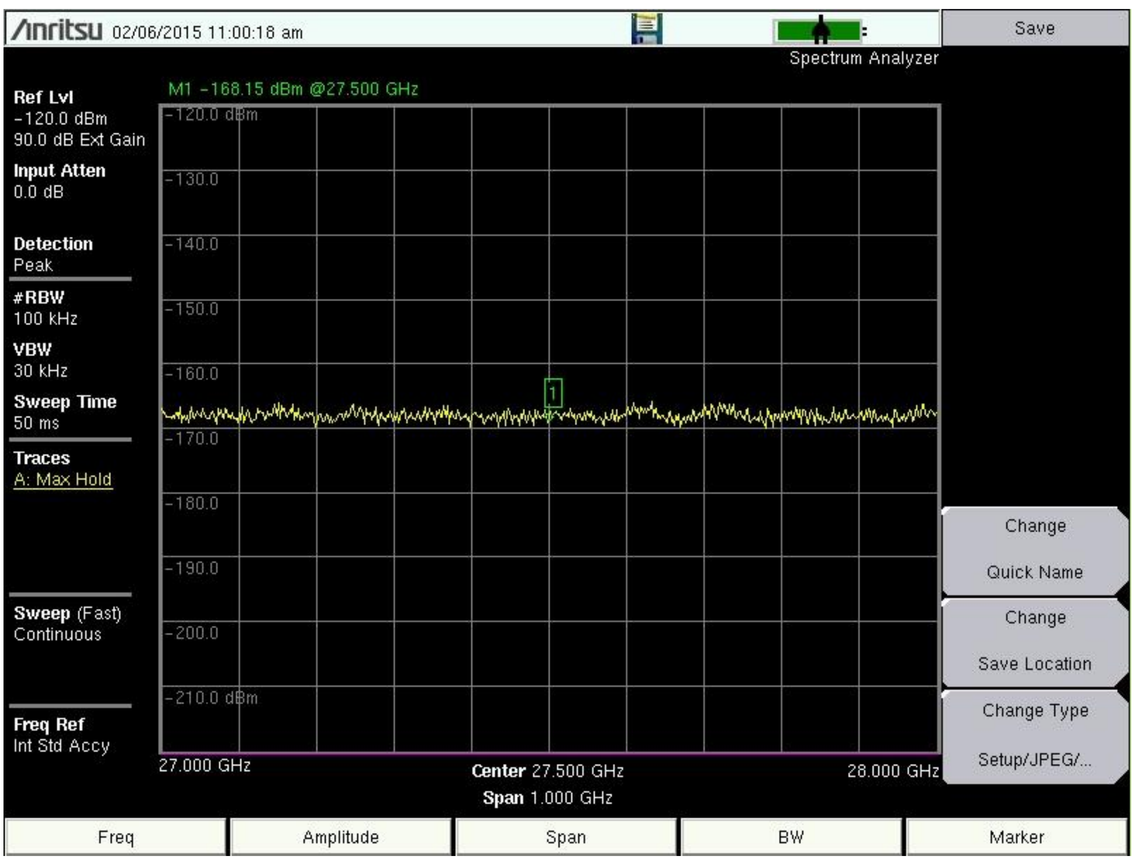

Figure 3.1-7 (D) Spectrum Photos 27-28 GHz 100 KHz Res BW Vertical Pol 360^0

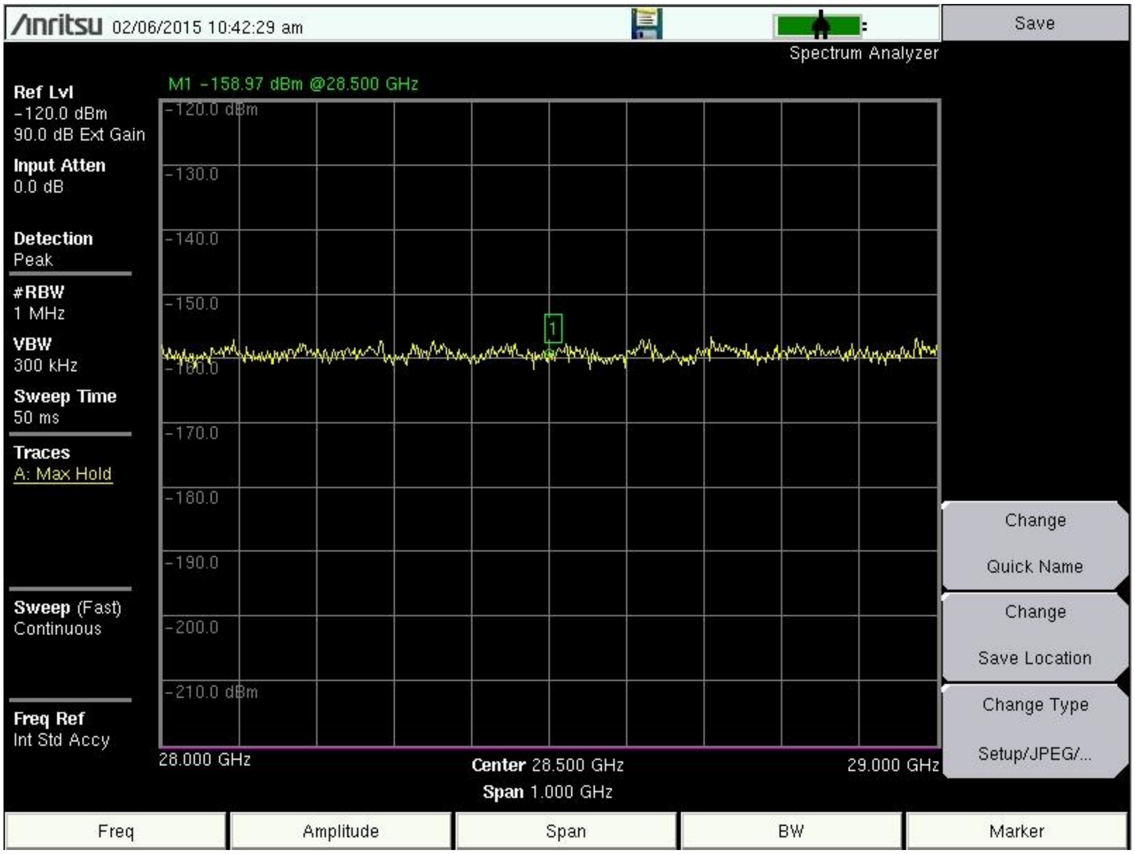

Figure 3.1-8 (A) Spectrum Photos 28-29 GHz 1MHz Res BW Horizontal Pol 360^0

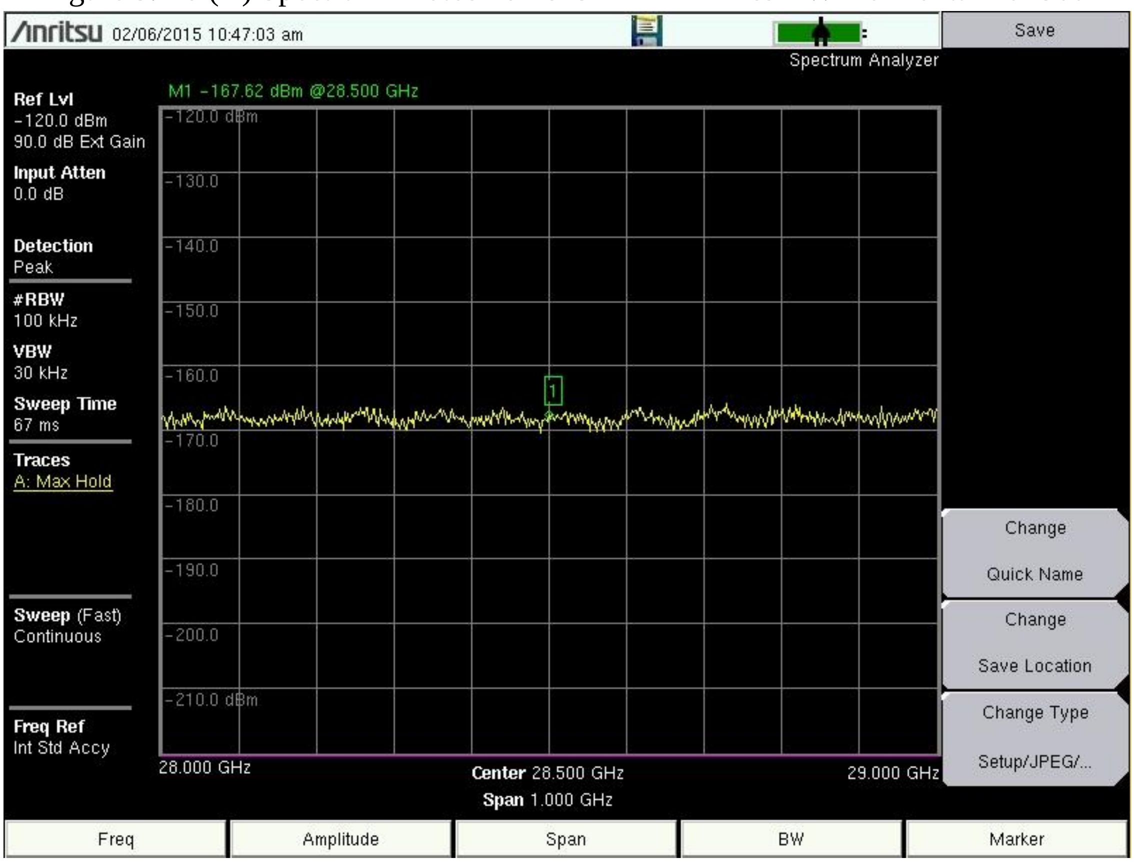

Figure 3.1-8 (B) Spectrum Photos 28-29 GHz 100 KHz Res BW Horizontal Pol 360^0

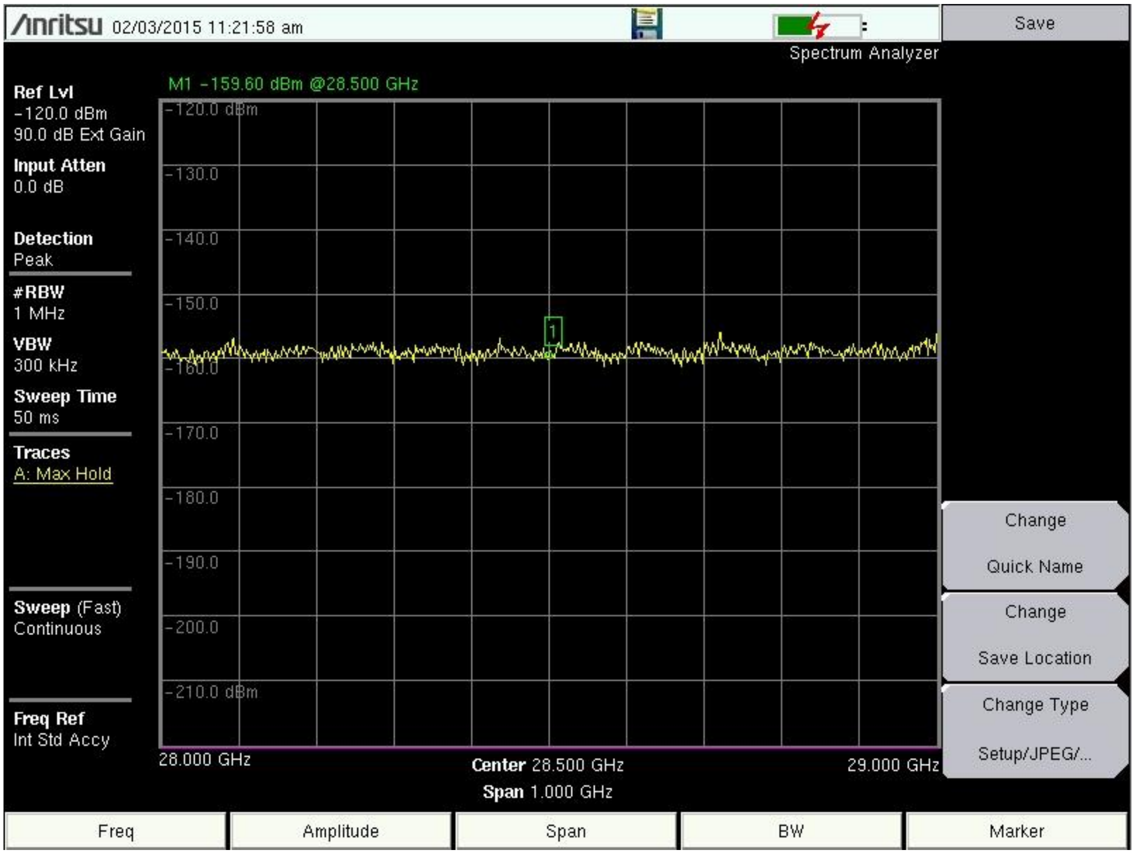

Figure 3.1-8 (C) Spectrum Photos 28-29 GHz 1MHz Res BW Vertical Pol 360^0

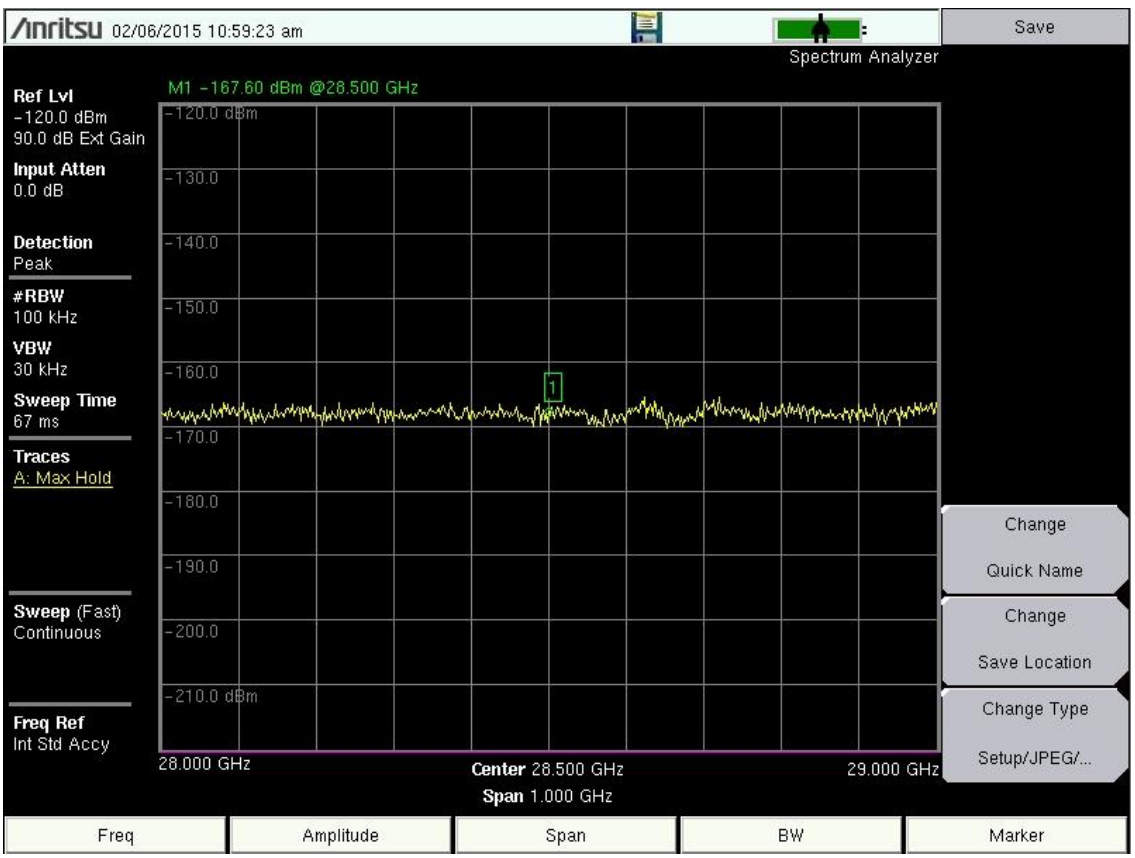

Figure 3.1-8 (D) Spectrum Photos 28-29 GHz 100 KHz Res BW Vertical Pol 360^0

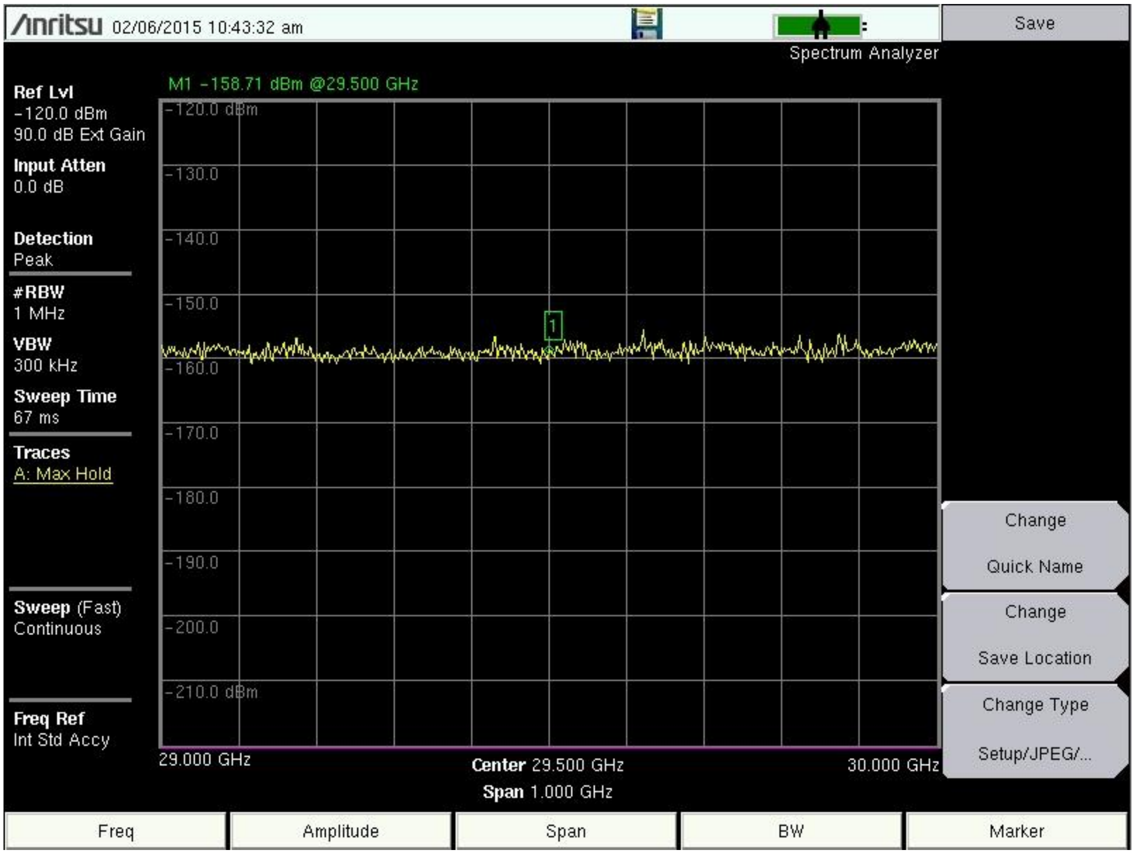

Figure 3.1-9 (A) Spectrum Photos 29-30 GHz 1MHz Res BW Horizontal Pol 360^0

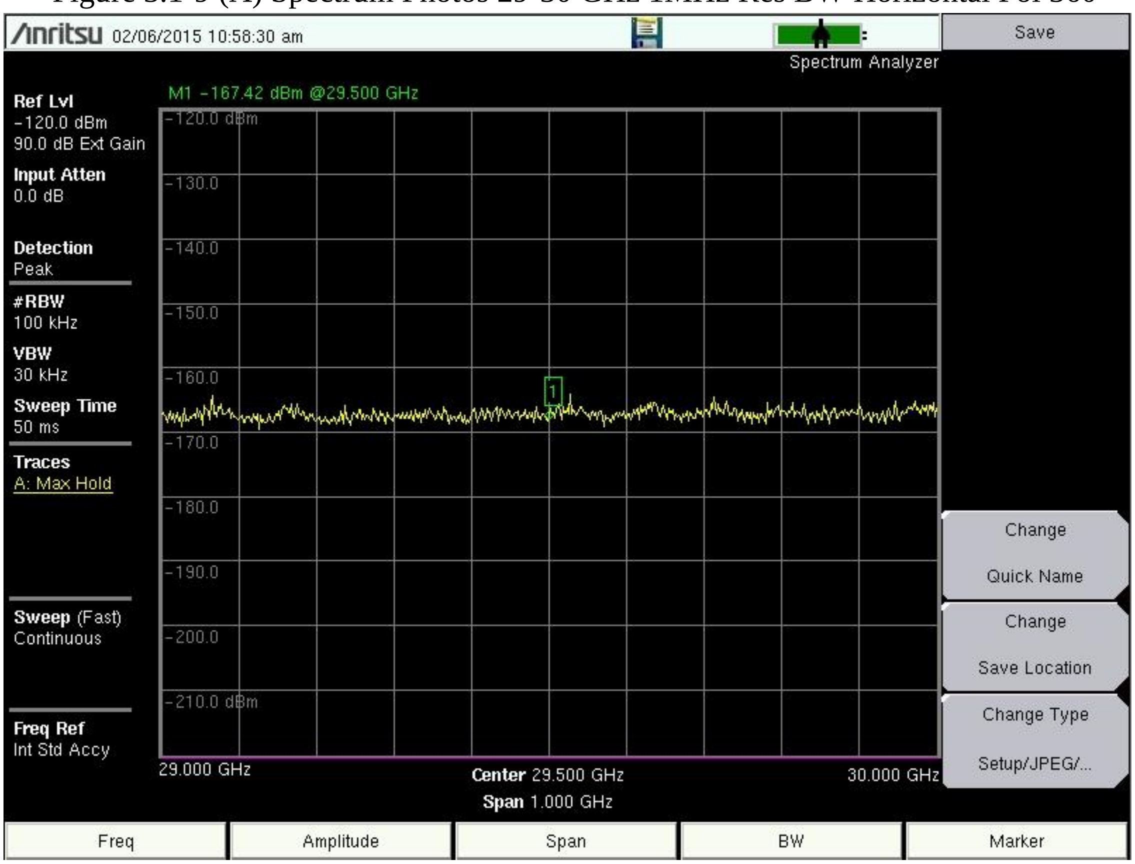

Figure 3.1-9 (B) Spectrum Photos 29-30 GHz 100 KHz Res BW Horizontal Pol 360^0

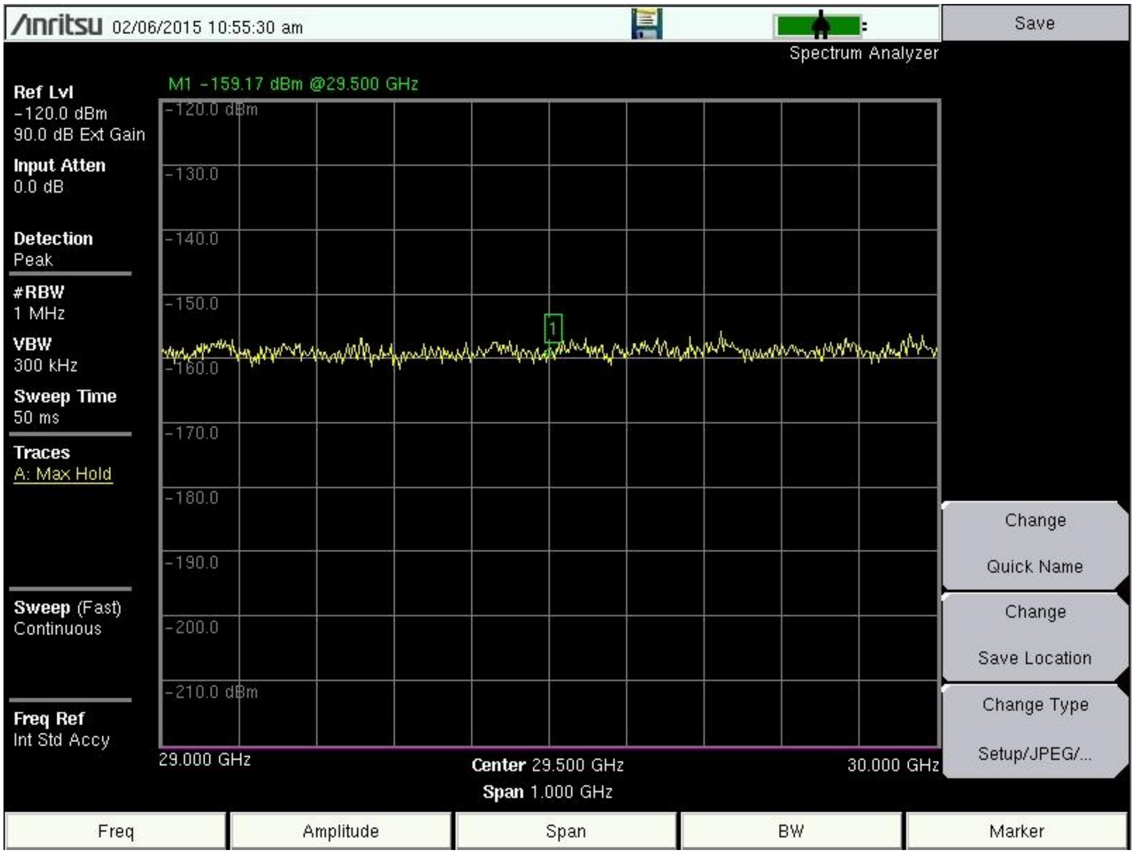

Figure 3.1-9 (C) Spectrum Photos 29-30 GHz 1MHz Res BW Vertical Pol 360^0

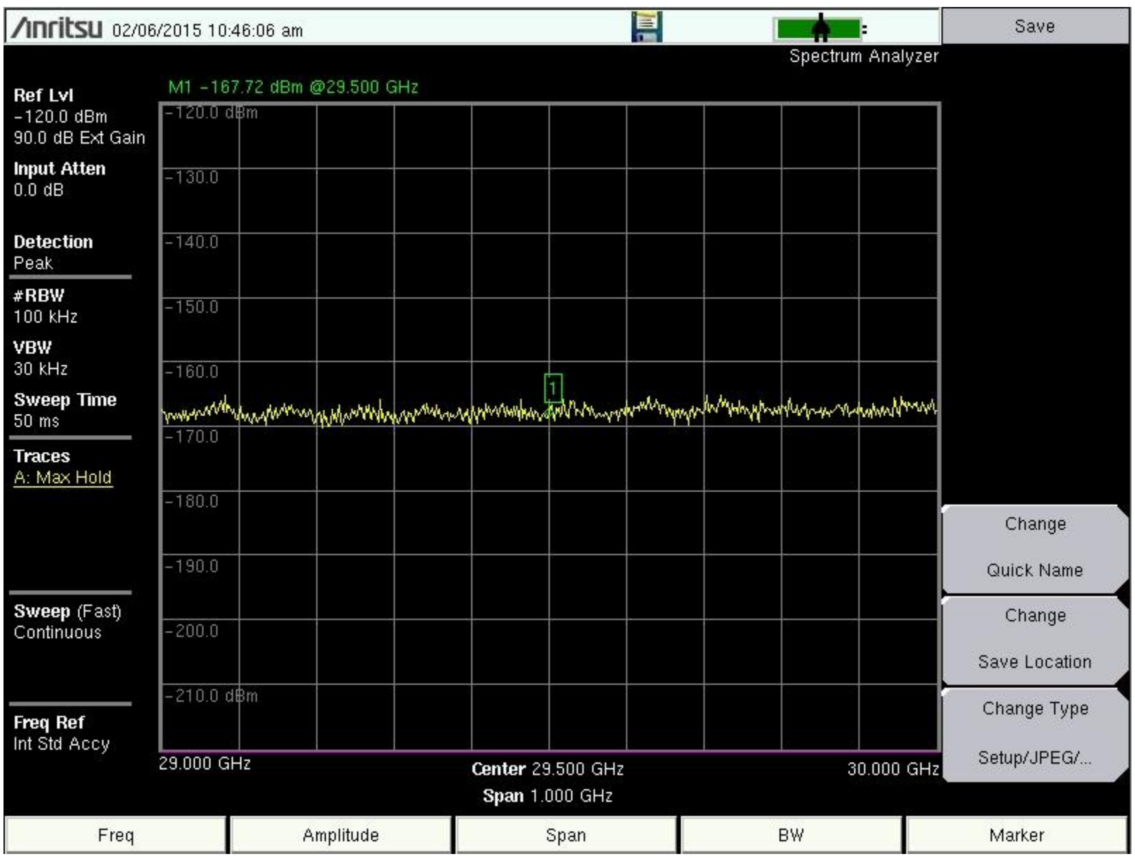

Figure 3.1-9 (D) Spectrum Photos 29-30 GHz 100 KHz Res BW Vertical Pol 360^0

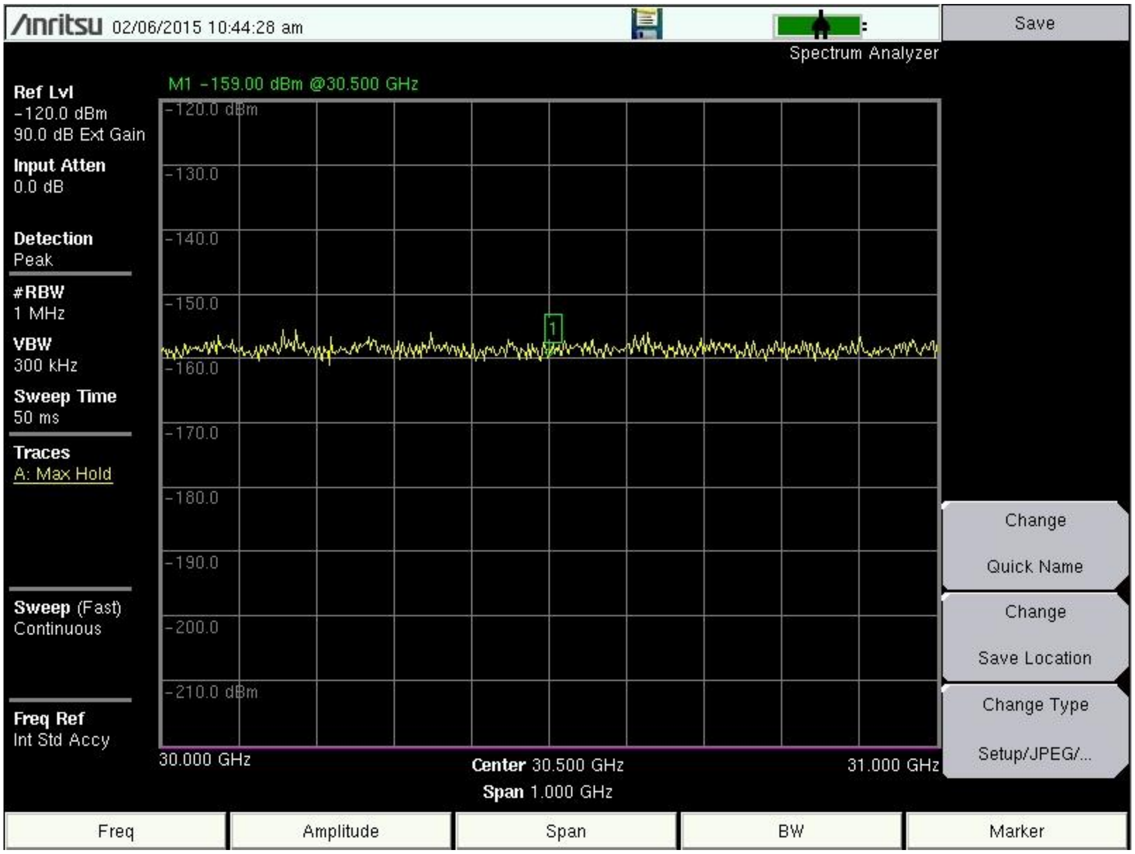

Figure 3.1-10 (A) Spectrum Photos 30-31 GHz 1MHz Res BW Horizontal Pol 360^0

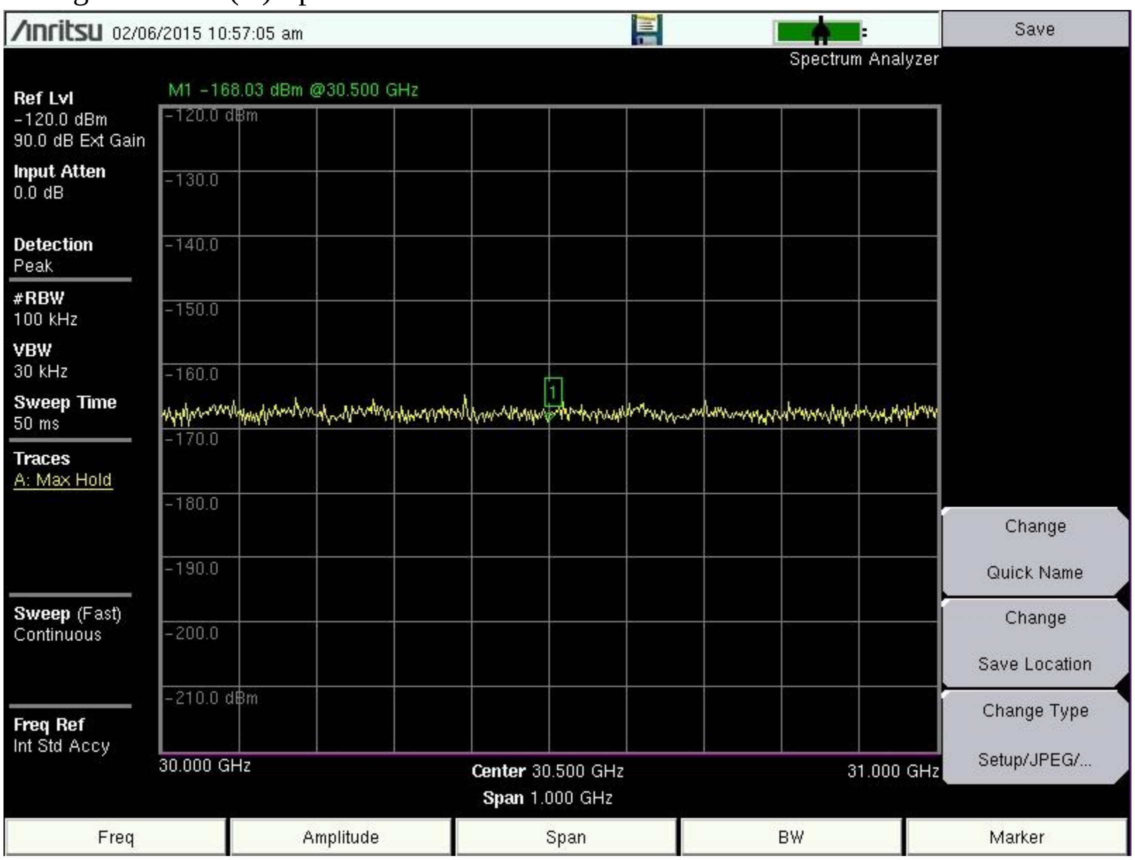

Figure 3.1-10 (B) Spectrum Photos 30-31 GHz 100 KHz Res BW Horizontal Pol 360^0

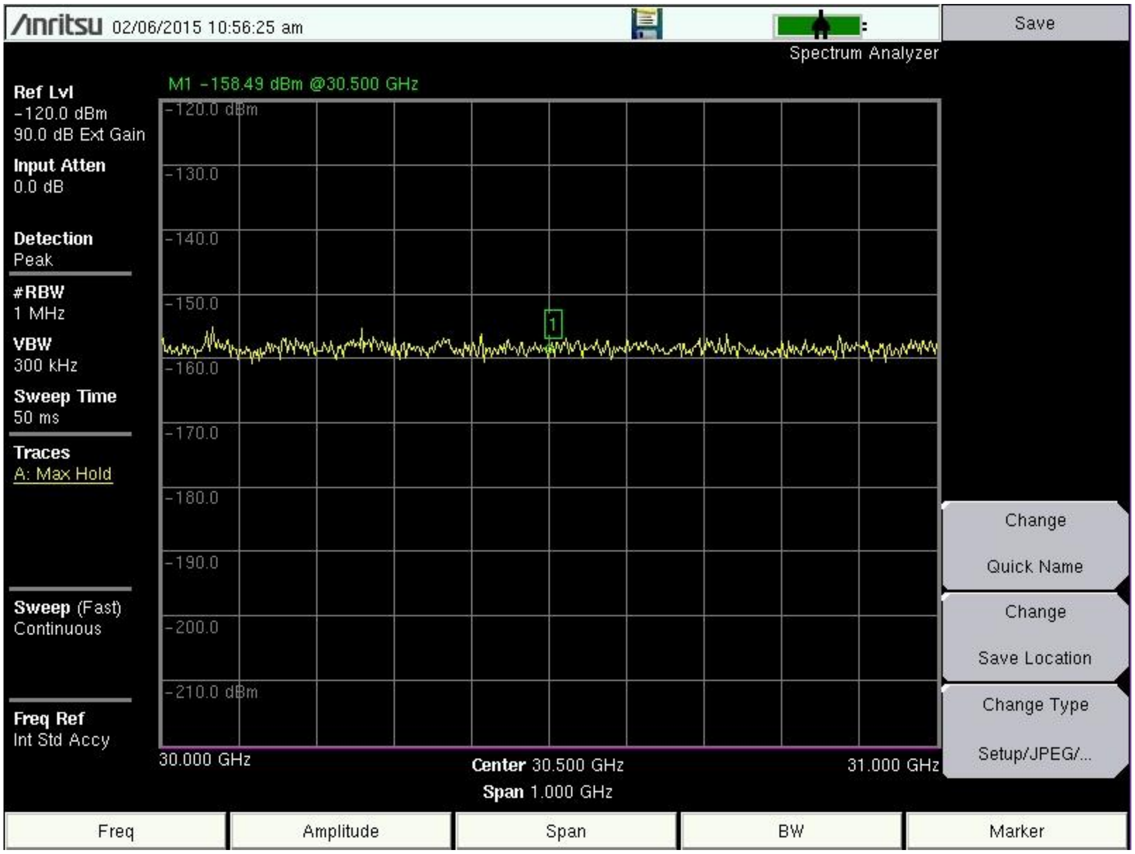

Figure 3.1-10 (C) Spectrum Photos 30-31 GHz 1MHz Res BW Vertical Pol 360^0

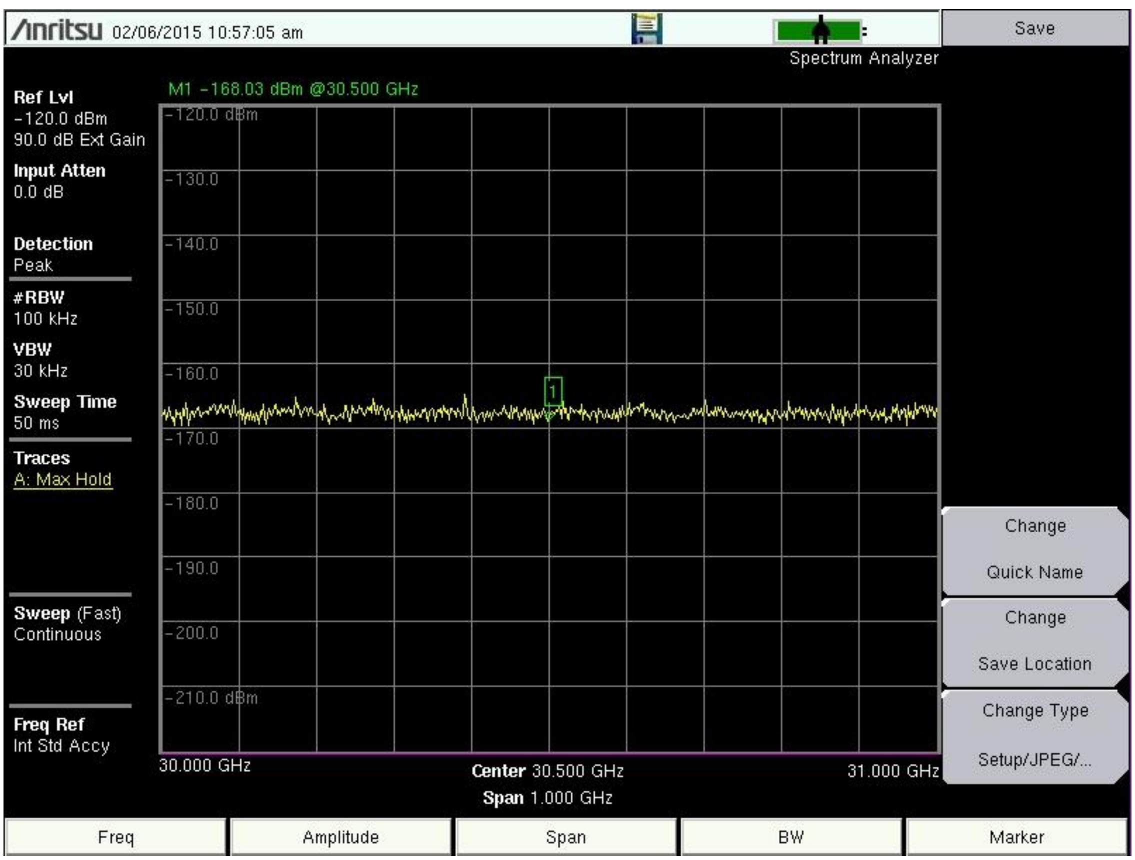

Figure 3.1-10 (D) Spectrum Photos 30-31 GHz 100 KHz Res BW Vertical Pol 360^0

SECTION

FOUR

SECTION 4

SUMMARY OF RESULTS

The results of the measurements conducted at the proposed ViaSat, Inc site in Columbus, OH are presented in this section.

Arc Clearance:

There is no potential satellite arc blockage at this site. Final arc clearance will depend on antenna placement.

Ku-Band Measurements:

There were no radio frequency interference cases measured at this site above the noise floor of the test equipment. Three cases were predicted.

SECTION

FIVE

SECTION 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

There were no signals measured above the –156 dBW/ 1 MHz interference objective for digital reception at this site.

The satellite arc has no potential blockage from 55W through 115W.

5.2 Recommendations

It is recommended that frequency coordination of this site be initiated to protect this location at the more stringent digital receive interference objective.